Oregon Agricultural College

Experiment Station

Director's Biennial Report 1922-1924

August, 1924

CORVALLIS, OREGON

The regular bulletins of the Station are sent free to the residents of Oregon who request them.

BOARD OF REGENTS OF THE OREGON AGRICULTURAL COLLEGE AND EXPERIMENT STATION

Hon. J. K. Weatherford, President	Albany
Hon. E. E. Wilson, Secretary	Corvallis
Hon. B. F. Irvine, Treasurer	Portland
Hon. Walter M. Pierce, Governor	Salem
Hon. Sam A. Kozer, Secretary of State	Salem
Hon. J. A. Churchill, Superintendent of Public Instruction	Salem
Hon. George A. Palmiter, Master of State Grange	Hood River
Hon. Mrs. W. S. Kinney	Astoria
Hon. Sam H. Brown	Gervais
Hon. Harry Bailey	Lakeview
Hon. Geo. M. Cornwall	Portland
Hon. E. B. Aldrich	Pendleton
Hon. Jefferson Myers	Portland

STATION STAFF

W. J. Kerr, D.Sc., LL.D.	President
J. T. Jardine, B.S.	Director
E. T. Reed, B.S., A.B.	Editor
H. P. Barss, A.B., S.M.	Plant Pathologist
F. D. Bailey, M.S.	Asst. Pathologist, Insecticide and Fungicide Bd., U. S. Dept. of Agri.
B. B. Bayles	Junior Agronomist, Office of Cer. Inves., U. S. Dept. of Agri.
R. S. Besse, M.S.	Associate in Farm Management
P. M. Brandt, B.S., A.M.	Dairy Husbandman
A. G. Bouquet, B.S.	Horticulturist (Vegetable Gardening)
E. N. Bressman, B.S.	Associate Agronomist
G. G. Brown, B.S.	Horticulturist, Hood River Br. Exp. Station, Hood River
W. S. Brown, A.B., M.S.	Horticulturist in Charge
D. E. Bullis, B.S.	Assistant Chemist
A. S. Burrier, M.S.	Assistant in Farm Management
Leroy Childs, A.B.	Supt. Hood River Branch Exp. Station, Hood River
G. V. Copson, M.S.	Bacteriologist
H. K. Dean, B.S.	Supt. Umatilla Branch Exp. Station, Hermiston
C. R. Donham, D.V.M.	Assistant Veterinarian
Theo. P. Dykstra, M.S.	Assistant Plant Pathologist, U. S. Dept. of Agri.
E. M. Edwards, B.S.	Asst. Animal Husbandman, East Ore. Br. Exp. Sta., Union
A. E. Engbretson, B.S.	Supt. John Jacob Astor Br. Exp. Station, Astoria
L. N. Goodding, B.A., B.S.	Jr. Plant Pathologist, U. S. Dept. of Agri.
W. V. Halversen, Ph.D.	Associate Bacteriologist
H. Hartman, M.S.	Associate Horticulturist (Pomology)
E. M. Harvey, Ph.D.	Horticulturist (Physiology)
Bertha C. Hite, B.A.	Scientific Assistant Seed Lab., U. S. Dept. of Agri. (Seed Analyst)
R. E. Hutchinson, B.S.	Asst. to Supt. of Harney Valley Branch Exp. Station, Burns
G. R. Hyslop, B. S.	Agronomist
W. T. Johnson, D.V.M.	Poultry Pathologist
I. R. Jones, Ph.D.	Associate Dairy Husbandman
J. S. Jones, M.S.	Chemist
G. W. Kable, M.S.	Agricultural Engineer
F. L. Knowlton, B.S.	Poultry Husbandman
A. G. Lunn, B.S.	Poultry Husbandman in Charge
M. B. McKay, M.S.	Plant Pathologist
H. G. Miller, Ph.D.	Chemist
G. A. Mitchell, B.S.	Asst. to Supt. of Sherman County Branch Exp. Station, Moro
Don C. Mote, M.S.	Entomologist
O. M. Nelson, B.S.	Animal Husbandman
R. K. Norris, B.S.	Assistant to Supt. of Southern Oregon Branch Exp. Station, Talent
A. W. Oliver, B.S.	Assistant Animal Husbandman
E. L. Potter, M.S.	Animal Husbandman
W. L. Powers, M.S.	Chief, Department of Soils
F. C. Reimer, M.S.	Supt. Southern Oregon Br. Exp. Station, Talent
R. H. Robinson, A.B., M.S.	Chemist
C. C. Ruth, M.S.	Associate Agronomist
C. V. Ruzek, B.S.	Associate in Soils (Fertility)
H. A. Schoth, M.S.	Asst. Agronomist, Forage Crops Investigation, U. S. Dept. of Agri.
C. E. Schuster, M.S.	Associate Horticulturist (Pomology)
H. D. Scudder, B.S.	Chief in Farm Management
H. E. Selby, B.S.	Associate in Farm Management
O. Shattuck, M.S.	Supt. Harney Valley Branch Exp. Station, Burns
J. N. Shaw, D.V.M.	Assistant Veterinarian
J. E. Simmons, M.S.	Assistant Bacteriologist
B. T. Simms, D.V.M.	Veterinarian
D. E. Stephens, B.S.	Supt. Sherman County Br. Exp. Station, Moro
R. E. Stephenson, Ph.D.	Associate Soils Specialist
B. G. Thompson, M.S.	Assistant Entomologist
E. F. Torgerson, B.S.	Assistant in Soils (Soil Survey)
E. H. Wiegand, B.S.	Horticulturist (Horticultural Products)
Joseph Wilcox, B.S.	Assistant in Entomology
Maud Wilson, B.S.	Home Economist
Robt. Withycombe, B.S.	Supt. Eastern Ore. Branch Exp. Station, Union
W. W. Yates, B.S.	Assistant Chemist
S. M. Zeller, Ph.D.	Plant Pathologist

CONTENTS

	Pages
INTRODUCTION	5
COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE	6
SOME OUTSTANDING STATION ACCOMPLISHMENTS OF THE BIENNIUM	7-8
ADDITIONAL AGRICULTURAL ENTERPRISES NEED STATION ASSISTANCE	8-9
PRESENT STATION INVESTIGATIONS NEED STRENGTHENING IN MANY LINES	10-12
SERVICE AND REGULATORY	12-13
THE STATION NEEDS GREENHOUSES, LAND, AND STORAGE	13-14
PUBLICATIONS	14-28
RESULTS OF INVESTIGATIONS UNDER WAY	28-98
Department of Animal Husbandry	28-30
Department of Dairy Husbandry	30-31
Department of Poultry Husbandry	31-33
Department of Veterinary Medicine	33-34
Department of Farm Crops	34-43
Department of Soils	43-50
Department of Agricultural Chemistry	50-52
Department of Bacteriology	53-56
Department of Farm Management	56-58
Department of Horticulture	58-66
Department of Botany and Plant Pathology	66-73
Department of Entomology	74-77
Branch Experiment Stations	77-98
John Jacob Astor Branch Station	78-79
Harney Valley Branch Station	80-82
Umatilla Branch Station	82-84
Hood River Branch Station	84-88
Sherman Branch Station	88-91
Southern Oregon Branch Station	91-96
Eastern Oregon Branch Station	96-98

August, 1924.

TO THE PRESIDENT OF THE COLLEGE

Sir:

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Oregon Agricultural College for the biennium ended June 30, 1924. It includes a brief account of the work and results during the two years, and again directs attention to urgent needs of the Station.

J. T. JARDINE,
Director.

Director's Biennial Report

OREGON AGRICULTURAL EXPERIMENT STATION

1922-1924

August, 1924

INTRODUCTION

The purpose of this report is to discuss briefly the work of the Oregon Agricultural Experiment Station for the two years ending June 30, 1924 and to indicate the outstanding needs of the Station for meeting important problems referred to it for solution. The report is in form and scope very similar to the Director's biennial reports for the two preceding periods and is intended as a part of a continuous record of the activities of the Station. The results of the investigations and their application to Agricultural industries of Oregon are more completely presented in the fifteen bulletins, thirty-one circulars, hundreds of press articles, and lectures from the Station during the two years.

As a whole the progress of the Station work has been satisfactory. The volume of work undertaken and the results secured were possible only as a result of continuous effort and a most excellent cooperation throughout the Station staff. As in the past there were many meritorious requests for investigations which could not be undertaken. This is to be expected if the efforts of Station workers in Oregon and elsewhere are reasonably effective in rendering assistance. In a state with so wide variation in climate, soils, and agricultural enterprises and possible new enterprises it can hardly be hoped that there will come a time when all investigations needed can be undertaken without delays.

Attention is again directed to necessity of small editions and their distribution only upon request in order to publish the results of investigations in bulletins and circulars as rapidly as new findings of value become available.

Also attention is again called to the time required in rendering service through letters, conferences, laboratory examinations, field days, and for field trips requested through the Extension Service.

COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE

The United States Department of Agriculture continued valuable cooperation in several important investigations and cooperation in new lines was undertaken. Of the Federal Bureau of Plant Industry the Office of Cereal Investigations continued cooperation in work of cereal improvement and diseases of cereals; the forage crop investigations were continued with the cooperation of the Office of Forage Crop Investigations; and during the biennium cooperation on a small scale was continued with the office of Cotton, Truck, and Forage Crop Disease Investigations in a study of nematode troubles; with the office of Pine Blister Rust Control in the Campaign to control White Pine Blister Rust; with the office of Drug, Poisonous, and Oil Plant Investigations in an effort to improve varieties of mint for Oregon conditions; and the cooperation of the Office of Fruit Disease Investigations was continued in a study of cranberry problems; seed testing was continued in cooperation with the Seed Laboratory; the Moro Branch Station was continued in cooperation with the Office of Cereal Investigations and the Branch Station at Hermiston in cooperation with the Office of Western Irrigation Agriculture Investigations. Cooperation with the Bureau of Chemistry for investigations of problems in horticultural products was active during part of the biennium; the soil survey in cooperation with the Bureau of Soils was continued; cooperation with the Bureau of Farm Management and Farm Economics in a study of Cost of Wheat Production was continued and assistance in Drainage Problems was given by the Division of Agricultural Engineering, Bureau of Public Roads.

SOME OUTSTANDING STATION ACCOMPLISHMENTS OF THE BIENNIUM

In the Director's Report for 1920-1922, a few illustrations were given of investigations which had reached a point to indicate results of outstanding benefits. Further mention of some of these items and others will serve best to illustrate the possibilities of assistance to agriculture through the Agricultural Experiment Stations.

The illustrations which follow are by no means a complete list. They report only a few investigations which have materialized in the past few years. The Station has had a part in the introduction or development of most of the crops now grown in the state; has been responsible largely for the development of spraying practices, and methods of pruning and cultural practices which enable orchardists of Oregon to compete with growers throughout the world. Assistance of like importance has been rendered in about every phase of the agricultural industry within the state.

FEDERATION WHEATS

The introduction and development of Federation wheats was mentioned as of importance in the last report. The expectations have been more than justified. In one important wheat-growing section of Umatilla county a single community profited to the extent of approximately

$60,000 due to the increased yields of these wheats in 1924 compared with yields of wheat previously grown. These wheats are doing much for the farmers and there is every promise that they will be more widely grown and of greater value still.

SMUT-RESISTANT WHEATS

The Director's last report mentioned promising results with pure line selections of wheat varieties immune to both species of stinking smut. Results during 1923 and 1924 further indicate possibilities of eventually having smut-resistant commercial wheats to replace the susceptible wheats now grown at great cost for control of smut. For three years, smut-resistant varieties have out-yielded the local Turkey wheat from 3 to 10 percent at the Moro Branch Station. Out of thirty-three varieties of wheat in five dry-farm nurseries in different counties in Eastern Oregon, a smut-resistant variety ranked third in average yield in 1924.

LEGUMES FOR WESTERN OREGON

Attention is again called to Hungarian vetch and its promising results in Western Oregon. This vetch has become definitely established. From the sixty-acre crop for seed in 1921, approximately 30,000 acres was grown for seed and forage in 1924. This vetch is now widely distributed throughout Western Oregon and in 1924 several car-loads were shipped to meet demand for seed from out-of-state.

Hairy vetch is showing promise for seed production. A considerable amount of this seed is imported each year. Seed grown in Oregon is of superior quality and there is good demand for it. The work of the Station in the development of methods of growing and harvesting this vetch and in the development of a non-shattering type is proving of value.

The many years of experimental work looking to the establishment of alfalfa in the Willamette Valley is beginning to bring success. There are about 100,000 acres of land suitable to the production of alfalfa in the Willamette Valley. The success of the Station with Grimm alfalfa and sulfur as a fertilizer with improved cultural practices followed by demonstrations is resulting in the development of alfalfa in the Valley.

PRUNE DRYING

The recirculation of air system for drying prunes to which attention was called in the last report has continued to prove of merit. Many fruit growers are erecting new driers or remodeling old ones according to suggestions and specifications from the Station. Drying by this method means a saving of one-half in wood cost, one-third in labor costs, and produces a better-dried product compared with the old natural-draft system. Further experimental work has made progress in adapting this system to the drying of nuts.

CHERRY AND FILBERT POLLINATION

Investigations on pollination of the sweet cherry have brought results of great economic value. The average production of cherry trees in the state is estimated from thirty to fifty pounds per tree. Individual

trees are known to be yielding as high as one thousand pounds. The Station has definitely established that much, if not most, of this difference is due to pollination. By choosing cherry pollenizers of known value in causing set of fruit on adjacent trees, it is possible greatly to increase the yield per tree in the future. This knowledge has already resulted in the top-working and interplanting of cherry orchards to secure proper pollination.

Investigations in cross-pollinating filberts have been brought to a conclusion with the publication of Oregon Station Bulletin 208, Filberts. By definitely establishing need for cross-pollination, the Experiment Station has made it possible to avoid mistakes similar to those in cherry plantings.

ADDITIONAL AGRICULTURAL ENTERPRISES NEED EXPERIMENT STATION ASSISTANCE

The Director's Report for the past biennium pointed out that it was not possible to meet all requests for assistance to new agricultural enterprises. The situation in this regard has not been remedied to any extent.

FIBER FLAX INDUSTRY NEEDS ASSISTANCE

The Experiment Station has been carrying on field tests with flax in a small way. The industry, however, is growing faster than our facts are accumulated. Especially is this true because the center of the fiber flax growing will be in Marion county, and soil conditions are somewhat different from those available for study at experiment stations. Aside from field studies in selecting and improving flax varieties, determining the best time and methods of seeding, and working out cultural practices for harvesting, investigations will be needed in connection with the conversion of the flax from the field into materials for the mills.

Investigations in this field should be under way at once, but cannot be undertaken.

THE BULB INDUSTRY NEEDS ASSISTANCE

The growing of bulbs in Oregon is rapidly increasing. In connection with this development, there are problems of disease and pest control and problems of culture. Requests for assistance are increasing. In cooperation with the Federal Department of Agriculture, some aid has been rendered in control of diseases and pests. As a whole, little has been undertaken. Undoubtedly this industry will develop to a point where information will be important to further success before the Station can collect the needed facts.

HOPS

This industry usually brings in from a million to three and a half million dollars a year and Oregon has the largest acreage of hops of any state in the United States. The Station has done some work on fertilizers, irrigation, and spraying, and has rendered chemical assistance

in a small way. Nothing has been done in the way of varietal testing, improvement, and cultural methods for this crop. Oregon's yield per acre is less than the other two important states, indicating that something is needed in this connection.

BROOM-CORN

Oregon manufacturers of brooms have, at times, expressed considerable interest in the development of home-grown broom-corn. Our experiments along this line have been exceedingly limited and of little consequence. There is a field for this work in parts of Jackson, Josephine, and Douglas counties, and in Umatilla, Morrow, and Malheur counties under irrigation. The manufacturers now ship in their supply almost entirely from Oklahoma and Kansas.

TOBACCO

A number of people have written from time to time about tobacco culture. Nothing is being done on this industry. Oregon conditions appear favorable for the growth of the crop.

GROWING ROSES FOR PERFUME

Requests of previous years have been repeated for the Oregon Station to conduct investigations to determine the practicability of establishing the commercial growing of roses in Oregon for the manufacture of perfume. There seems little doubt that the climatic and soil conditions are suitable for satisfactory production. There is little, if any, information available, however, as to the amount of oil which roses in Oregon are producing compared with similar varieties grown elsewhere. Also, there is the big problem of labor involved in this industry, compared with this item in Europe. It has been impossible to meet requests of people interested in this industry without giving up investigations of importance to industries in which large amounts of capital are already invested.

BEE INDUSTRY CALLS FOR ASSISTANCE

Bee growers in Oregon have requested assistance and their request has much merit. Oregon now has approximately 100,000 bee-keepers and $1,500,000 invested in bees and bee-keeping equipment. There appear to be opportunities for a much larger industry provided efficient management for local conditions is brought about.

There is need for study to determine the best management systems for different sections of the state, and for surveys of cost of producing honey. There is need also for further facts as to winter care and protection against diseases.

REQUESTS FOR SOIL SURVEYS CONTINUED

The soil surveys in cooperation with the Federal Bureau of Soils have continued, and requests outstanding at the time of the last Director's Report have largely been taken care of. There are requests from additional counties and covering special areas which will more than require continuation of the work for the next two years unless the forces are enlarged, which seems improbable.

PRESENT STATION INVESTIGATIONS NEED STRENGTHENING IN MANY LINES

In the Director's Report for the past biennium, attention was called to a number of problems not adequately taken care of. Attempt has been made to strengthen the program along the lines indicated but accomplishment in this respect has been limited.

Diseases of small fruits became alarming and it was necessary to discontinue other work in order to assign the full time of the plant pathologist to the study of mosaic and related disease of brambles.

Animal nutrition in relation to production and diseases was called to attention in the last report as needing thorough investigation. A well-organized investigation was undertaken in this field during the biennium covered in this report.

Aside from these two new lines of investigation, the need for strengthening the Station program is still a problem of the future. The following are a few of the more important lines:

COST OF PRODUCTION AND FARM MANAGEMENT STUDIES

The need for thorough-going investigations was stressed in the Director's last report. The importance of accumulating information in this field has grown during the two years since that report. Data on cost of production, on farm organization, and combinations of farm enterprises are needed as never before as a basis for readjustment to changing conditions of labor, transportation, and the markets.

The Station staff and the Extension Service staff have cooperated in undertaking a limited amount of work in this field, but the need is greater than ever for organized, continuous investigations.

MARKETING INVESTIGATIONS

The need of systematic studies in the marketing of products of Oregon agriculture is again called to attention. Practically nothing has been attempted in this field by the Experiment Station staff. The problems are of such a nature that little will be accomplished without the best effort and full time of at least one well-qualified staff member. The expansion of the Station program to this extent is not practicable with the funds and facilities now available.

VEGETABLE GARDENING

The Horticulture department of the Station has been carrying on investigations of limited scope in the field of vegetable gardening. The industry has grown faster than our program of investigations, both in magnitude and in need for additional facts. There is, no doubt, opportunity for expansion of Oregon agriculture in this field. The Station investigations should be materially strengthened along this line at the earliest possible opportunity.

FARM CROPS PROBLEMS

In the reports for each of the previous biennium periods attention has been called to the need for strengthening investigations on farm crops problems aside from enterprises specifically discussed. Much has been accomplished along this line, but there is still a need for developing and strengthening the Station program, and in this field especially for Western Oregon. More thoroughly proved facts regarding forage crops and grains suited to the different soils and climates are important, and there are few places where the ways in which the soil is worked and the time and method of planting crops need more careful study. The problems of weed control, pasture development and maintenance, and standardization of crops are big questions still.

SOIL INVESTIGATIONS

The Station program in the fields of soil fertility, soil management, drainage, and irrigation needs strengthening.

Soil fertility investigations should be expanded to include more field trials with fertilizers, and laboratory and greenhouse studies should be materially strengthened. There has been improvement in this respect during the past two years, but more is needed.

Drainage is still an important problem in Western Oregon, and in the irrigated sections. Considerable experimental work has been undertaken but more is needed, especially in connection with reclamation and irrigation of lands which might be subject to injury from excess of alkali. There are probably three million acres of Oregon lands which will eventually need drainage and they are so situated as to be valuable future lands.

There is still much to be learned in the use of irrigation water. The amount of water, rather than the land, is the limiting factor in reclamation in some areas and the use of more water than is necessary in all cases is expensive, and in some cases dangerous, because of injury to the crops and permanent injury to the land.

A volume might be written on this subject, but the brief statements here given will be ample support for the statement that the Station program should be strengthened in this field along the lines indicated as soon as possible.

CROP PEST AND HORTICULTURAL PROBLEMS

Breeding, cultural, and fertilizer problems of small fruits are still in need of investigation. The small fruit acreage more than trebled from 1909 to 1922. The estimated acreage in 1922 in Oregon was 16,500 acres. The increase has been due, in no small measure, to the fine quality of fruit and especially to the high yields obtained. To maintain high yields and high quality, it is necessary to understand the problems of fertility, culture and maintenance of vigorous stock. There is ample evidence of need for further facts on each of these questions as related to the maintenance of a profitable industry.

The problems of orchard fertility in Oregon have, by no means, decreased since they were called to attention in the last report of the

Director. More and more evidence is accumulating to indicate the importance of soil, soil fertility, and soil management in the production of profitable fruit crops. The possibility of increasing financial returns and of preventing waste in the use of fertilizer is great.

An investigation of small-fruit diseases has been undertaken during the biennium and will be continued. The time of one man, however, will make possible only investigation of certain diseases of brambles and minor observations in connection with other troubles. The Station investigations in the control of insect pests of small fruits has been somewhat strengthened but is still inadequate and should be increased.

The need still exists for investigations in connection with control of walnut blight and filbert bacteriosis.

DISEASES OF CATTLE AND SHEEP

There is need for investigation of losses due to causes presumed to be diseases among range cattle and range sheep in the state. The Station responds to calls for assistance at times but little can be accomplished until there is a thorough-going investigation into the losses, their character, and causes.

SERVICE AND REGULATORY

MISCELLANEOUS

As in previous years, the Station staff was called upon to render assistance in many ways aside from that reported under investigations under way. This service, through correspondence, field examinations, conferences with growers and groups of growers, laboratory tests and Station field days, and lectures, no doubt ranks high in service to Oregon agriculture. At times, such service is a costly interruption to experimental work under way. On the other hand, the staff members are thus kept in close contact with the practical problems of the farmers and are better qualified to plan and carry out investigations with a clear objective.

As illustrations of the extent of service rendered, the Department of Veterinary Medicine made over 6,000 agglutination tests for abortion, aside from those in connection with experimental work; about 2,000 laboratory diagnoses; about 700 office conferences with livestock owners; and about 100 visits to farms at the request of the farmers. Dr. B. T. Simms, head of the department, spent over one month on foot-and-mouth disease observations in California on behalf of the state. In addition, there were, approximately, 2,200 inquiries replied to by letter.

The Department of Horticulture examined 450 specimens of canned goods; assisted in the installation of 40 systems of recirculation driers; answered perhaps 12,000 letters, using as a basis the facts from experimental work; and scarcely a day passed without one to many inquiries by visits to the office. The departments of Plant Pathology, Entomology, Farm Crops, Soils and Irrigation, Animal Husbandry, Dairy Husbandry, Poultry Husbandry, and Chemistry each met a volume of service as large or larger than that stated for Veterinary Medicine and Horticulture.

A like service is rendered by each of the seven branch experiment stations.

STATION FIELD DAYS

During each of the two years, field days were held at each of the stations. At the Central Station, Corvallis, a week of field days was held. Farmers from counties of the Willamette Valley came in groups under the leadership of their respective county agents. The entire Station staff was available on these days to conduct the visitors over the Station work and direct attention to experiments and findings of particular value to farmers of the respective counties. Similar field days were held annually at each branch station. In this way, many farmers have appreciated, as never before, the possibilities of the experiment stations as a means of solving their problems and bringing to them the best crops and practices for their respective districts without expensive trials by the farmers individually.

REGULATORY

The Experiment Station staff administer the Fertilizer Inspection Law, the Lime Law, the Insecticide and Fungicide Law, the Dairy Bull Registration Law, and the Stallion Registration Law. Brief statements regarding this work are included under the respective departments.

THE STATION NEEDS GREENHOUSES, LAND, AND STORAGE

GREENHOUSES

In the report two years ago the urgent need for greenhouse space was called to attention. The Experiment Station is still limited to one small section of greenhouse. The situation is becoming desperate. Important projects must be deferred or undertaken ineffectively. The most simple needs of Experiment Station workers with soils, crops, and plant diseases cannot be met. Some way must be found to provide better greenhouse service.

LAND

The urgent need for land also has been pointed out in the past two reports. Most of the land under use is rented. It is difficult to secure a lease for a longer period than five years and, in many cases, one year is the limit. This arrangement, obviously, is unsatisfactory for many phases of Experiment Station work with field crops and soils. Obviously, no horticultural plantings can be undertaken under such conditions.

The need for a new orchard site was discussed at some length in the Director's Report for the past biennium. Gradually the old orchard is dying out and is not being replanted. As stated in the last report, there is almost no hope of bringing into bearing a commercial orchard or of growing, with any assured success, trees or small fruits for experimental purposes. Either land must become available for horticultural work at the Home Station or there will develop an effective demand for horticultural work at other branch stations similar to the ones at Talent and at Hood River.

Land is a primary need for a new orchard and for the experimental work in field crops, soils, and the management of lands under use by livestock at the Central Station.

The Hood River Branch Station should have land and buildings. This need is realized by the growers and Hood River county has under consideration the expenditure of $35,000 for these facilities. It is hoped that the plan will materialize by 1925.

SEED HOUSE AND STORAGE HOUSE

The Experiment Station is still without adequate storage facilities. Space is needed for service by all departments. In the 1920-1922 Report the difficulty of saving valuable seed stock was called to attention. In the fall of 1924, immediately after that report, many valuable seed stocks were destroyed by the fire which burned the horse barn. The only storage available was in a shed beside the barn.

Cold storage facilities are much needed, especially for harvesting and storage investigations of fruits and vegetables.

REPAIRS AND REPLACEMENTS

During the biennium the improvement of the cottage, paint, general repairs, and new fencing for the south poultry farm were secured. These were much-needed improvements. The plant is now in good working order.

Many desired additions and changes in laboratories and office space were secured. These help materially in maintaining efficiency of the Station workers.

Needed improvements were secured at the Union, Burns, and Talent branch stations. The Astoria Station has reached the point where improvements in the buildings are imperative.

EQUIPMENT

The need for additional equipment was mentioned in the last report. The most urgent needs have now been met. Additional equipment is being added as rapidly as possible. This is no longer considered a limiting factor.

PUBLICATIONS

The Director's report for the biennium ending June 30, 1922, explained the necessity of printing small editions of Station bulletins and circulars, in order to publish promptly Experiment Station results available with our limited funds. This policy was continued during the biennium and even greater effort than in former years was made to get material in printed form promptly, so that it could be made use of by the people of the state.

Fifteen Station Bulletins and thirty-one Station Circulars were prepared and issued during the two years. In addition, original research data from a number of projects were published in leading technical journals of the country and in the Journal of Agricultural Research.

The difficulty of meeting requests for publications under this plan of small editions was called to attention in the Director's Report for the biennium ending June 30, 1922. With the increasing effectiveness of Extension workers throughout the country, and development of agricultural work in high schools, the demand for copies of Experiment Station publications continues to increase. Requests for one dozen or more copies of a Station Bulletin or Circular are not uncommon. The total requests are far in excess of the number of copies in the average edition. It is necessary, therefore, to dispense with individual mailing lists, and it is not possible to furnish individual copies for use as text-books, either in high schools or colleges. Attempt is made to secure cooperation so that a few copies furnished to teachers and libraries can be made of service to large numbers of people. The library and institutional mailing list under this policy has been much increased. To further aid in more effective distribution of publications, a list of available bulletins and circulars is sent out periodically to persons who have asked that they receive the Station publications. Individual copies of bulletins and circulars requested are furnished when available. In this way one will receive only such publications as he is particularly interested in, instead of receiving these and many others, as is customary where the mailing list for all publications is maintained.

There is complaint occasionally because new publications are exhausted within a few months. Libraries, however, have copies on file and a small reserve is held by the Station to meet emergency needs. It is considered advisable, therefore, to continue the present policy in order to issue results and recommendations from the Experiment Station work as promptly as facts are available which will be of service to the agricultural industries of the state. This can be done with funds available only by issuing small editions prepared in form as brief as may be consistent with effective presentation. The following publications were issued during the biennium.

BULLETINS

Number	Title	Edition	Pages
191	Growing Irrigated Crops in Harney Valley	5,000	20
192	Infectious Abortion of Cattle	8,000	12
193	Fattening Steers (1922 Edition)	6,000	20
194	Oats and Vetch Versus Corn or Sunflowers for Silage	5,000	20
195	Stump Land Reclamation in Oregon	8,000	64
196	Finishing Pigs for Market	8,000	24
197	A Chemical Study of Legumes and Other Forage Crops of Western Oregon	5,000	24
198	Fattening Lambs on Alfalfa	3,000	16
199	Sulfur in Relation to Soil Fertility	5,000	48
200	A Study of Growth in Summer Shoots of the Apple With Special Consideration of the Role of Carbohydrates and Nitrogen	4,000	52
201	The Preparation of Spray Materials	6,000	16
202	The Relation of Humidity to the Texture, Weight, and Volume of Filberts	5,000	24
203	Forage Crops for Oregon Coast Counties	5,000	32

Number	Title	Edition	Pages
204	Spring Crops for Eastern Oregon	6,000	36
205	Drying Prunes in Oregon	5,000	28
	Soil Report of Washington County (In Cooperation U. S. Dept. Agric., Bureau of Soils).		
	Soil Report of Benton County (In Cooperation U. S. Dept. Agric., Bureau of Soils).		
	Soil Report of Josephine County (In Cooperation U. S. Dept. Agric., Bureau of Soils).		
	CIRCULARS		
26	Rise, Development, and Value of the Agricultural Experiment Station	10,000	40
27	Pollination of the Sweet Cherry	1,000	4
28	Filberts	1,000	8
29	Destroy the Earwigs	2,000	4
30	Copper Carbonate for Wheat Smut Control	2,000	4
31	Commercial Fertilizers	2,000	16
32	Strawberries	8,000	16
33	Oregon Experiment Station Trap-Nest	10,000	4
34	Field Peas	2,000	2
35	The Cherry Fruit-Fly	5,000	4
36	The Hop Red Spider	3,000	4
37	The Onion Maggot	5,000	4
38	The Peach and Prune Twig-Miner	5,000	4
39	Tree Borers and Their Control	3,000	8
40	Recirculation Driers	8,000	12
41	Official Testing of Dairy Cattle in Oregon	5,000	40
42	Insect Pests and Diseases of Currants and Gooseberries	8,000	12
43	Grape Growing in Oregon	5,000	16
44	Crop Rotation and Soil Fertility	5,000	12
45	Insect Pests and Diseases of Bramble Fruits	10,000	16
46	Hungarian Vetch in Oregon	5,000	4
47	Drainage and Improvement of White Land and Similar Wet Land	3,000	8
48	The Cane Fruit Industry in Oregon	10,000	28
49	Mosaic and Other Systemic Diseases of Brambles in Oregon	8,000	16
50	Control of the Western Peach and Prune Root-Borer	5,000	4
51	Building Plans and Bill of Material for O.A.C. 400-Hen Laying House	10,000	8
52	The O.A.C. Portable Colony House	10,000	8
53	Brown-Rot and Related Diseases of Stone Fruits in Oregon	6,000	20
54	Open Air Range House	5,000	8
55	Economic Results in the Pollination of Greenhouse Tomatoes	5,000	16
56	Cost of Producing Pork	5,000	12

JOURNAL OF AGRICULTURAL RESEARCH

Action of Sodium Nitrite in the Soil

SUMMARIES OF PUBLICATIONS

Station Bulletins

191. **Growing Irrigated Crops in Harney Valley,** Obil Shattuck and Douglas W. Ritchie.

Reports, experiments, and results of irrigation investigations at the Burns Branch Station for the years 1917 to 1921, inclusive. Suggestions are given relative to winter and spring crops, and varieties most successful under irrigation, the economical amount of water for each crop, and the best date and rate of seeding for each crop.

192. **Infectious Abortion of Cattle,** B. T. Simms and Fred W. Miller.

A brief statement of investigations and results over four years. The economic losses in Oregon due to prevalence of infectious abortion among dairy herds, cause of the disease, methods of spread, symptoms, methods of diagnosis, duration and outcome of the disease, treatment and methods of control and eradication are discussed.

193. **Fattening Steers,** E. L. Potter and Robert Withycombe.

This bulletin covers the entire subject of fattening steers under Western conditions and includes not only data published in Bulletin 174, Fattening Steers, now out of print, but additional data accumulated during the biennium. The findings are summarized as follows: (1) Alfalfa hay alone produced a daily gain of .97 pound when fed to two-year-old steers. The steers were given a daily ration of 37 pounds, of which they refused 5 pounds. (2) Chopping alfalfa hay for fattening steers increased the gains and saved waste. One ton of chopped hay made 13 percent more gain than one ton of long hay. The cost of chopping in these tests was about $3.00 a ton. Under normal conditions this amounts to more than the increased value of the chopped hay. (3) Alfalfa hay and grain produced 30 percent more daily gain than hay alone. One pound of rolled barley replaced three pounds of alfalfa hay. It made but little difference whether a small ration of grain was fed throughout the entire feeding period or a heavy feed of grain during the latter part of the period. (4) Alfalfa hay and silage produced 64 percent more gain than hay alone, while the daily feed cost was approximately the same. The steers fed hay and silage were fatter and dressed out more than those fed hay alone. Alfalfa hay and corn silage, or peas and barley silage, make the most economical and satisfactory ration for fattening two-year-old steers for the Western market. (5) Meadow pasture produced a daily gain of 1 pound during the first month, 2.39 pounds the second month, 2.31 pounds the third month, and .7 pound the fourth month. Steers finished on pasture topped the market. (6) Management of fattening steers to produce good gains requires that one handle the cattle gently, make feed-yard conditions comfortable, use a good quality of feed stuffs, feed regularly, use care in the selection of the feeder cattle, and feed nothing but good, thrifty, individuals of a beef breed.

194. **Oats and Vetch Versus Corn or Sunflowers for Silage,** Roy C. Jones.

This bulletin reports briefly the results of three years' comparative feeding trials of oats and vetch, sunflowers, and corn silage with dairy cows. Thirty-two different animals were under test. The bulletin points

out that oats and vetch on heavier soils produces more tonnage than corn or sunflowers, fills the silo in early summer and is available for summer use if desired, is planted in the fall when other farm work is less rushing than in spring when corn and sunflowers are planted, and requires no cultivation after sowing. Vetch is a legume and is therefore a soil builder and in the tests conducted produced slightly more milk than either corn or sunflowers. For these reasons more oats and vetch for silage in Western Oregon is recommended.

195. **Stump Land Reclamation in Oregon,** H. D. Scudder.

In this bulletin the importance of stump land reclamation in future agricultural development is indicated by figures and discussion of present and prospective stump lands in the Northwest. Old methods of clearing are discussed briefly but the bulletin mainly reports results of experiments and demonstrations with a new stump burner method using the Zysset burner.

196. **Finishing Pigs for Market,** A. W. Oliver and E. L. Potter.

This bulletin summarizes all of the Experiment Station work in fattening pigs and shows methods of feeding and relative values of all of the standard Oregon feeds, such as barley, wheat, corn, oats, middlings, shorts, mill-run, bran, cocoanut meal, skim milk, buttermilk, tankage, oil meal, fish-meal, potatoes, rutabagas, silage, garbage, etc.

197. **The Chemical Study of Legumes and Other Forage Crops of Western Oregon,** J. S. Jones and D. E. Bullis.

The value of legumes in rejuvenated run-down soils is briefly discussed. Tabulated analytical data for the commonly grown legumes and other forage crops are given and commented on from the standpoint of animal nutrition.

198. **Fattening Lambs on Alfalfa,** E. L. Potter and H. K. Dean.

Results of various experimental tests in fattening lambs with alfalfa supplemented by various grain and grain and silage combinations are given, aimed particularly for the alfalfa raiser who is looking to the fattening of lambs as a means of marketing surplus alfalfa hay. The more important points of the bulletin may be summarized as follows: (1) Good, thrifty lambs will gain one-third pound per day and will be fat in from forty to ninety days. (2) It requires three hundred pounds of grain and nine hundred pounds of alfalfa to put on one hundred pounds of gain with fattening lambs. (3) The standard ration on the alfalfa farms is one pound of whole grain and three pounds of alfalfa. (4) One ton of grain is worth three tons of hay for fattening purposes. (5) Lambs may be fattened on as little as three-fourths pound of grain per day when grain is expensive, or as much as one and one-half pounds per day when grain is cheap. (6) Grains are best fed without grinding and hay without chopping. (7) Barley, wheat, oats, corn, or any mixture of these, are good for fattening lambs. (8) Silage has a feeding value of from 40 to 70 percent of that of good alfalfa hay, depending upon the kind and quality of the silage.

199. **Sulfur in Relation to Soil Fertility,** W. L. Powers.

This bulletin reports experiments on the value of sulfur applied to alfalfa throughout the chief alfalfa-growing sections of Oregon. A com-

plete report of field sulfur fertilizer experiments is presented. Many Oregon soils are found to be low in sulfur. Alfalfa requires five pounds or more of this element per ton. Drainage water from soil bins contains several times as much sulfur as is received in the annual precipitation. In certain experiments striking increases are secured by sulfur while soluble calcium, potassium, phosphate, or nitrate applied to these soils gave little or no increase, strongly indicating that sulfate is lacking in the soil solution in amount needed for best growth. Inoculated sulfur has shown little advantage.

200. **A Study of Growth in Summer Shoots of the Apple With Special Consideration of the Role of Carbohydrates and Nitrogen,** E. M. Harvey.

It was reported in the above bulletin, that in normal-growing apple shoots relatively large chemical differences obtain between the terminal, middle, and basal regions. That rather constant growing conditions prevail in the terminal portion of the shoot throughout the growing season is indicated by the fact that substances commonly associated with good growth conditions are not only more abundant in the tip, but decrease there less rapidly. The growth of apple shoots was found to be affected by ringing and defoliation, according to the stage of development. For example, early in the growing season, ringing retarded growth, later accelerated growth, and finally, again retarded it. Chemical changes in the shoots as affected by ringing and defoliation were closely followed. Such chemical changes recorded were thought to have thrown some light upon the specific growth responses. A general explanation was offered to unify the diverse growth responses of shoots to ringing and defoliation. Also the general application of these findings was made to the pruning problem.

201. **The Preparation of Spray Materials,** R. H. Robinson.

Reports information on the best methods of preparing all spray materials that may be home-prepared. Several new sprays worked out in the Station laboratories are described.

202. **The Relation of Humidity to the Texture, Weight, and Volume of Filberts,** Henry Hartman.

This bulletin reports the water content of filberts which increases or decreases with the relative humidity of the air in which they are kept. Even within the range of common relative humidity, the water content of filberts varies sufficiently to affect materially the texture, weight, and volume. It has a bearing upon such operations as gathering, drying, grading, and storing. Filberts are susceptible to the attacks of decay organisms, and should be gathered and dried as soon as they fall to the ground. Excessive drying is not desirable nor necessary. Storing under living-room conditions seems to be satisfactory. It is not advisable to keep filberts fresh during the entire storage period. They should be dried down to a safe water content and allowed to regain their moisture only when about to be consumed. Refreshing restores the original texture and plumpness, and improves the cracking quality. The use of certain wrapping mediums such as paraffin paper does much to prevent evaporation after refreshing.

203. **Forage Crops for Oregon Coast Counties,** Albert E. Engbretson and George R. Hyslop.

This bulletin reports results of experiments at the Astoria Branch Station over a period of some ten years. Data are included indicating the importance of the dairy industry in Oregon coast counties, the acreage, kind, and production of hays and forage in these counties and the apparent need for more legumes. Experimental data and suggestions are given as to suitable legumes, roots, soiling crops, and pasture mixtures and how to grow them on coast tide-lands and hill lands.

204. **Spring Crops for Eastern Oregon,** David E. Stephens, Robert Withycombe, and Obil Shattuck.

This bulletin reports experimental data and experience in growing spring crops east of the Cascades in Oregon. This area is essentially a winter crop country but there is a considerable area of spring crops and occasionally winter damage to some necessitates reseeding to spring crops. Results of the stations at Moro, Union, and Burns over a period of years are reported. Crops and varieties together with data and suggestions on planting, growing, etc., are given.

205. **Drying Prunes in Oregon,** Ernest H. Wiegand.

This bulletin treats of the evolution of the evaporator and the need for better standardization of the dried product to be brought about by better sanitation in handling, including the preparation of fruit for drying. Suggestions are made regarding the growing and harvesting of fruit, and phases of preparation such as grading, dipping and traying. Under the subject of drying, the two general types of evaporators (1) natural draft and (2) mechanical draft, are considered. The effects of temperature, humidity, and circulation of air upon the dried product are noted. The methods of dipping the fresh fruit in lye before drying are discussed and experimental data given in comparison with the method of ordinary hot water dipping. Suggestions on processing, packing, and marketing are given. This bulletin stresses the proper relation of drying factors to obtain quality. The proper temperature, humidity and air circulation have been approximated by these experiments, and are as follows: Temperature 150° to 165° F.; circulation 600 to 750 lineal feet per minute; humidity 15 percent to 30 percent.

Soil Survey Report of Washington County, C. V. Ruzek and A. L. Fluharty, Oregon Experiment Station, and E. B. Watson and E. C. Eckmann, United States Department of Agriculture.

This survey covers an area of 467,840 acres. Location, topography, climate, agricultural development, and adaptability of soils are discussed in the report, which describes each soil type, its location, extent, characteristics, possibilities, and reclamation or improvement.

Soil Survey Report of Benton County, Oregon, E. J. Carpenter, United States Department of Agriculture, and E. F. Torgerson, Oregon Experiment Station.

The Benton county soil survey covers 414,720 acres. The county soil map is on a scale of one inch to a mile and shows each soil type with a different color. All landmarks such as roads, buildings, and streams are shown so that the farmer can determine the type or types of soil in each quarter-section of land. The report describes the climate, agriculture, topography of the area; the kind and yield of crops on each soil type, together with a description of each type and suggestions for its improvement.

Soil Survey Report of Josephine County, A. E. Kocher, United States Department of Agriculture, and E. F. Torgerson, Oregon Experiment Station.

The area surveyed includes 489,600 acres; topography, climate, location, agricultural development, and adaptability of soils are discussed in the report, which describes the soil types, their extent, possibilities, reclamation and improvement.

Station Circulars

26. **Rise, Development, and Value of the Agricultural Experiment Station,** James T. Jardine.

A brief popular statement of the history of agricultural experiment stations, their function and some of their accomplishments. Outstanding accomplishments of the Oregon Experiment Station and their money value to the agriculture of Oregon are reported.

27. **Pollination of the Sweet Cherry,** C. E. Schuster.

This circular contains a brief statement of the results of the pollination work carried on at The Dalles in 1922. All commercial varieties are self-sterile while the Bing, Lambert, and Napoleon are inter-sterile. A list of varieties is given that are used successfully in cross-pollination on these varieties. Black Republican and Centennial are among the best pollenizers.

28. **Filberts,** C. E. Schuster.

This is a short discussion of general culture accompanied by directions for efficient cross-pollination of the Barcelona variety which is the commercial variety of this section. Du Chilly, Nottingham, Daviana, and White Aveline are good pollenizers.

29. **Destroy the Earwig,** B. B. Fulton.

A concise account of the method of control of the European earwig by the scattering of poison bran mash.

30. **Copper Carbonate for Wheat Smut Control,** H. P. Barss.

A statement of the advantages and limitations of copper carbonate for wheat-smut control and directions for its use.

31. **Commercial Fertilizer,** R. H. Robinson.

This circular reports the chemical analyses of inspected samples and compares their guaranteed and found composition. General information on plant foods present in various fertilizer materials, together with their commercial value are discussed.

32. **Strawberries,** C. E. Schuster.

This circular discusses such topics as location, soils, cultivation, and other problems. A list of varieties is given with their special suitability to localities and markets.

33. **Oregon Experiment Station Trap-Nest,** Alfred G. Lunn and Frank L. Knowlton.

A description of the single compartment trap-nest developed and found to be satisfactory in breeding work at the Oregon Experiment Station. Working plans and bill of materials for construction are included.

34. **Field Peas,** G. R. Hyslop.

A brief statement of field peas in Oregon agriculture with information as to varieties and methods of growing.

35. **The Cherry Fruit-Fly,** A. L. Lovett.

A brief description of the maggot and adult fly is given, followed by recommendations for control under Oregon conditions. The period for effective control is limited, but cherries are worth the effort required to protect them, and the cost of the treatment is low.

36. **The Hop Red Spider,** A. L. Lovett.

The red spider-mite on hop causes serious injury during a season of prolonged drouth accompanied by high temperatures. Sulfur in some form is the standard control for the red spider. Two spray formulas are given together with a brief statement of the life-history and habits of the hop red spider.

37. **The Onion Maggot,** A. L. Lovett.

A brief account of the onion maggot and the onion thrips. The "cull onion" treatment for the onion maggot developed in British Columbia gives promise of excellent results in tests made at the Oregon Experiment Station. The method of procedure is given, also the sweetened poison bait formula with methods of application, the standard control recommended in the East.

Good farming is the very best control for onion thrips.

38. **Peach and Prune Twig-Miner,** A. L. Lovett.

A brief popular account of the pest with effective control recommendations.

39. **Tree Borers and Their Control,** A. L. Lovett.

The circular states that fruit-tree borers in general attack successfully only devitalized trees. The following are discussed briefly with control recommendations: flat-headed borer, shot-hole borer, bronze apple-tree weevil.

40. **Recirculation Driers,** E. H. Wiegand. 1923.

This circular discusses the advantages of recirculating the air in driers; shows the possibility of remodeling the Oregon tunnel drier; gives directions for building new driers and estimates the cost of installing and operating the recirculation system of drying.

41. **Official Testing of Dairy Cattle in Oregon,** H. N. Colman.

42. **Insect Pests and Diseases of Currants and Gooseberries,** A. L. Lovett, H. P. Barss.

43. **Grape Growing in Oregon,** C. E. Schuster. 1923.

This circular discusses the development and possibilities of grape-growing in Oregon, especially for limited local consumption and not for

long shipments. Various cultural subjects are discussed, such as sites, soil, cultivating, and pruning for American and European grapes. The better varieties for this section are given.

44. **Crop Rotation and Soil Fertility,** W. L. Powers and C. V. Ruzek.

This circular deals with crop rotation as an aid in maintaining the productiveness of our soils; it reviews progress of soil-building rotations under study at the Home Station since 1914. Benefits of rotation; essentials of a good rotation; suitable rotations for Western Oregon; and value and use of farm manure, are discussed. Suggestions regarding the use of fertilizers are included.

45. **Insect Pests and Diseases of Bramble Fruits,** A. L. Lovett and H. P. Barss.

46. **Hungarian Vetch in Oregon,** H. A. Schoth.

A description and discussion of the new vetch, Hungarian vetch, distributed to farms first in 1920 after eleven years of trial by the Oregon Experiment Station in cooperation with the Federal Office of Forage Crops. This promising vetch grown on ½-acre by a farmer in 1920 increased to 200 acres in 1923. Directions for planting, growing, and harvesting the crop are given.

47. **Drainage and Improvement of White Land and Similar Wet Lands,** W. L. Powers.

A popular report is made of experiments which have been worked out, establishing depth, capacity, and distance for tile for drainage of white land. Methods of handling tiled white land to secure the highest results from drainage are reported. There are half a million acres of similar wet lands as those under the experiment where an experimental drainage system was installed in 1914. Prior to drainage in 1914 the experimental field was frequently a third covered with surface water, and winter crops or clover could not be successfully grown. Drainage has made it possible to increase yields until this last season an average yield of 65 bushels of winter barley was obtained. Alsike clover yielded 2 tons in one cutting in 1922 without treatment. With lime the yield was 2.45 tons, limed and manured 2.9 tons, on this drained land.

48. **The Cane Fruit Industry in Oregon,** Henry Hartman.

The importance of the cane fruit industry in Oregon is noted. The yields of cane fruits in Oregon are compared with yields in other parts of the country. Advice is given regarding varieties, soils, and such cultural practices as pollination, propagation, duration of plantation, drainage, soil fertility including commercial fertilizers, pruning and trimming, the handling of the crop, and drying certain of the cane fruits.

49. **Mosaic and Other Systemic Diseases of Brambles in Oregon,** S. M. Zeller.

A brief statement covering history of systemic diseases of brambles, mention of the different types of these diseases, symptoms and nature of mosaic and of bramble-streak, method of spread, control, and need of experimental work.

50. **Control of the Western Peach and Prune Root-Borer,** D. C. Mote.

A brief practical account of the control methods recommended based on investigations carried on to date. Paradichlorobenzene, when applied in early fall with soil temperature high and soil moisture low, will kill 90 percent or more of the borers.

51. **Building Plans and Bill of Materials for O.A.C. 400-Hen Laying House,** Frank L. Knowlton.

52. **The O.A.C. Portable Colony House,** Alfred G. Lunn.

A description of the house accompanied by plans, specifications, and bill of materials.

53. **Brown-Rot and Related Diseases of Stone Fruits in Oregon,** H. P. Barss.

The nature of brown-rot and related troubles is described. The author discusses natural conditions promoting or retarding brown-rot, control measures, materials used in control. A summarized control program for brown-rot is given.

54. **Open Air Range House,** Frank L. Knowlton.

A discussion of the house, together with plans, specifications, and bill of materials.

55. **Economic Results in the Pollination of Greenhouse Tomatoes,** A. G. B. Bouquet.

This circular is a report on investigations conducted since the publication of Station Bulletin 158, Pollination of Tomatoes in 1919. It describes the tomato flower in its relation to pollination, the methods of artificial pollination, and tells of the performance necessary in the pollination of blossoms. Details of crop production are given noting how the crop can be materially increased by pollination and by the proper selection of high-producing and early-setting plants.

56. **Cost of Producing Pork,** E. L. Potter, H. A. Lindgren, and A. W. Oliver.

A study of the cost of pork based upon many years of investigation. Owing to constant fluctuations in market values, costs are expressed in terms of amounts of feed and labor rather than in dollars and cents.

Journal of Agricultural Research

Action of Sodium Nitrite in the Soil, Vol. XXVI, No. 1, R. H. Robinson.

This is a discussion of a study of nitrification and action of the new commercial fertilizer "Soda Nitrogen." The conclusion is reached that it could not be recommended for use on acid soils.

Technical Papers

Owing to limited funds for publication a number of technical manuscripts reporting original data and results of research were published in technical journals rather than as technical bulletins of the Station series. In addition the shorter papers listed here by title only were published in journals.

Soil Series and Types from the Standpoint of Hydrogen-Ion Concentration and Lime Requirement, J. S. Jones, Soil Science, Vol. XVIII, No. 1.

The Hydrogen-ion concentration in soils of Benton county is given and interpreted from the point of view of crop production.

Powdered Bordeaux Mixture, R. H. Robinson, Journal of Industrial and Engineering Chemistry, Sept., 1923.

A method is suggested for the preparation of a high grade bordeaux mixture.

The Use of Skim Milk in Preparation of Spray Materials, R. H. Robinson, Journal of Economic Entomology, June, 1924.

The preparation of the new spray as a substitute for summer strength sulfur sprays, the use of skim milk as an emulsifier for mineral oil sprays, and as a substitute for commercial casein spreaders, are discussed.

Spreaders for Insecticides and Fungicides, R. H. Robinson.

Paper read before the annual meeting of the American Chemical Society in Washington, D. C., in 1923.

Powdered Bordeaux Mixture, R. H. Robinson.

Paper read before the American Chemical Society at Washington, D. C. 1923.

Recent Advances in Preparation of Spray Materials, R. H. Robinson, Yakima Fruit Grower, Yakima, Washington.

Influence of Potassium on Urinary Sodium and Chlorine Excretion, H. G. Miller, Journal of Biological Chemistry, 55: 47.

Similar to the results of Bunge, it was found that an increase of potassium salt in the diet caused an immediate increase in urinary sodium and chlorine excretion. This increase, however, was only transitory, as with continuous potassium feeding, the amounts of sodium and chlorine excreted by way of the kidney decreased so that considerable portion of the ingested sodium chloride did not appear in the urine.

Potassium in its Relation to the Growth of Young Rats, H. G. Miller, Journal of Biological Chemistry, 55:62.

The growth of rats was greatly retarded by reducing the potassium content of the ration below one-tenth percent level. The response of the animals to increased potassium depended upon what growth stage potassium salts were given. The substituting of sodium for potassium does not support the physiological functions necessary for growth. A high ratio of potassium to sodium does not prove deleterious to growth.

Mineral Metabolism Studies with Dairy Cattle, H. G. Miller, P. M. Brandt, and R. C. Jones, American Journal of Physiology.

High-producing dairy cows in the early period of lactation were fed the ordinary dairy rations of Oregon. The animals were found to be in a negative calcium and phosphorus balance. When these rations were supplemented with bone meal, the retention of calcium and phosphorus increased to such an extent that the balances became positive. Kale was found to have a favorable effect upon mineral storage.

Studies on Sulfur Oxidation in Oregon Soils, W. V. Halversen, Soil Science, Vol. 16, No. 6, pp. 479-490.

Progress of Oregon Sulfur Investigations, W. L. Powers, Journal of American Society of Agronomy.

Functions of Sulfur in Relation to Soil Fertility, W. L. Powers, Soil Science.

Effect of Sulfur on the Soil Solution, R. E. Stephenson and W. L. Powers, Soil Science.

Land Reclamation Problems in Eastern Oregon, W. L. Powers, Reclamation Congress Report.

Important Small Fruit Diseases in Oregon, H. P. Barss, 17th. Bien. Rep. Ore. St. Bd. Hort. 196-198, 1923.

Mushroom Root Rot of Fruit Trees, H. P. Barss, 17th. Bien. Rep. Ore. St. Bd. Hort. 171-176, 1923.

Peach Tree Protection, H. P. Barss, 17th. Bien. Rep. Ore. St. Bd. Hort. 159-161.

Bacterial Gummosis of Cherry, H. P. Barss, 17th. Bien. Rep. Ore. St. Bd. Hort. 152-154.

Menace of the White Pine Blister Rust, H. P. Barss and Geo. A. Root, 17th. Bien. Rep. Ore. St. Bd. Hort. 220-226, 1923.

A Serious Nematode Disease of Strawberry and Clover in Oregon, M. B. McKay, 17th. Bien. Rept. Ore. St. Bd. of Hort. 177-182, 1923.

Cytospora Canker of Apple and Pear, S. M. Zeller, 17th. Bien. Rep. Ore. St. Bd. of Hort. 162-164, 1923.

European Canker of Pear and Apple, S. M. Zeller, 17th. Bien. Rep. Ore. St. Bd. of Hort. 155-157, 1923.

A Contribution to Our Knowldge of Oregon Fungi, S. M. Zeller, Mycologia 14:173-199. *Fig. 1-6,* July, 1922.

Sphaeropsis malorum and Myxosporium corticola on Apple and Pear in Oregon, S. M. Zeller, Phytopathology 14:329-333, 1924.

Leucogaster and Leucophlebs in North America, S. M. Zeller, (Revised and sent to Press Feb. 1924) Ann. Mo. Bot. Gard.

Coryneum Ruborum Ond. and Its ascogenous stage, S. M. Zeller, Mycologia.

Is it Maltose or Phloridzin that is Abundant in Apple Tissue? E. M. Harvey, Am. Jour. Bot. 10: 288-293, 1923.

Filbert Pollination, C. E. Schuster.

A paper delivered before the Western Nut Growers Association and printed in 1922 in Proceedings of the Society.

Cherry Pollination, C. E. Schuster.

A paper given before the annual meeting of the Northwest Horticulturists, Entomologists, and Plant Pathologists in 1923.

Selling Research to the Farmer, W. S. Brown.

Paper delivered before the American Society of Horticultural Science during the annual meeting of the A. A. A. S. at Boston, Massachusetts, December 1922 and published on page 200 of the "Proceedings."

Handling the Black Raspberry, W. S. Brown.

Paper read before Pacific Northwest Fruit Exposition held at Seattle, Washington, November 15, 1922.

Insect Pests of Truck and Garden Crops, by A. L. Lovett, 17th. Bien. Rept. Ore. State Board of Hort.

A brief description of the insect pests and nature of the injury with life-history and methods of control. The insects are treated under the following headings: General Pests; Potato and Tomato Insects; Bean and Pea Insects; Cabbage and Radish Insects; Cucumber, Cantaloupe, and Squash Insects; Onion Insects; Corn Insects, followed by a description of insecticides, the contact sprays, and stomach poisons.

The Cherry Fruit-Fly, A. L. Lovett, 17th. Bien. Rept. Ore. State Board of Hort.

In this article a brief description is given, with life-history and habits, injury, and the formula for the sweetened poison bait spray with methods and time of application.

The Loganberry Crown-Borer, A. L. Lovett, 17th. Bien. Rept. Ore. State Board of Hort.

A brief account of the history of the loganberry crown-borer in Oregon, together with the life-history, habits, and control methods. Control studies were undertaken which resulted in the recommendation of hand methods in control which has been found very satisfactory. The pest may be successfully controlled in commercial plantings at comparatively little expense.

The European Earwig, B. B. Fulton, 17th. Bien. Rept. Ore. State Board of Hort.

Ousting the Prune Root-Borer, F. H. Lathrop, Better Fruits, Aug. 1922.

Spray Program for Pacific Northwest, Lovett and Barss, Better Fruit, Feb. 1923.

Tree Hopper as an Apple Pest, A. L. Lovett, Better Fruit, Mar. 1923.

How to Curb Cherry Fruit-Fly, A. L. Lovett, Better Fruit, July, 1923.

Earwig as a Horticultural Menace, A. L. Lovett, Better Fruit, Aug. 1923.

Codling-Moth, A. L. Lovett, Oregon Grower, Aug. 1922.

Let's Whip the Codling-Moth in '23, A. L. Lovett, Oregon Grower, Feb. 1923.

The Codling-Moth in 1922, A. L. Lovett, Oregon Grower, Oct. 1922.

The Mediterranean Fruit-Fly and Quarantine, A. L. Lovett, Oregon Grower, Feb. 1923.

Cherry Fruit Maggot, A. L. Lovett, Oregon Grower, May 1923.

Fall Sprays for Blister-Mite on Apples, A. L. Lovett, Oregon Grower, Dec. 1923.

San Jose Scale Serious, A. L. Lovett, Oregon Grower, Jan. 1924.

The European Earwig, A. L. Lovett, Oregon Grower, Aug. 1923.

The Three Cornered Tree Hopper as an Apple Pest, A. L. Lovett, Wenatchee Fruit Grower, Mar. 1923.

Some Experiments on Poison Baits for the European Earwig, B. B. Fulton, Jr. Econ. Ent. 1923, Vol. 16, p. 369-376.

Popular Articles

Several hundred popular articles were published in Journals, magazines, and newspapers.

RESULTS OF INVESTIGATIONS UNDER WAY

Progress and results of the main investigations under way are indicated briefly in the following pages. The reports by departments and Branch Stations are essentially as prepared by department heads and station superintendents.

DEPARTMENT OF ANIMAL HUSBANDRY

IMPORTANT ACCOMPLISHMENTS TO DATE

Fattening lambs. The possibilities of lamb fattening as a means of marketing surplus alfalfa have been demonstrated. It has also been shown that the use of expensive imported corn is quite unnecessary and that high classed finished lambs can be produced on alfalfa supplemented with native grains as either oats, wheat, or barley fed unground and either with or without silage.

Garbage for pigs. It has been demonstrated that while garbage is not suitable for young pigs, shoats that have reached a weight of 75 to 100 pounds may be fattened on a ration of garbage alone, and when so fed will acquire a satisfactory finish and produce good pork. It has also been demonstrated that uncooked garbage produces satisfactory pork and that without any unusual risk from disease. Disease is prevented by vaccination and proper sanitation, and not by cooking of garbage.

Farm sheep. Our investigations in the cost of producing sheep, together with investigations in methods of wintering and pasture yields, show that the farms of Western Oregon and of the irrigated sections of Eastern Oregon can successfully compete with the range as producers of wool and mutton.

Finishing steers on silage. It has been demonstrated that steers fattened on silage dress out satisfactorily, and that shrinkage in transit is in no way unusual.

INVESTIGATIONS

Investigations of this department are carried on at the Central Station at Corvallis, and at the Branch Station at Union. The results of the Union station are reported under that head.

Hogs. The work of the last biennium, following the same general plan as that of previous years has been to ascertain more accurately the feeding value of common Oregon feeds. As we have already determined the value and uses of all our more common cereals and commercial feeds, attention has been devoted recently to waste products, particularly to garbage and to waste products of the orchard. The results with garbage are indicated on a preceding page under the head of "Important Accomplishments." The work with waste horticultural products has raised some rather important nutritional problems which it will take time to solve.

Probably the most important development in our hog work of the past biennium has been our publications. We have codified and summarized in brief, readable form the results of more than twenty years of work in two comparatively small publications; namely Oregon Station Bulletin 196, "Finishing Pigs for Market," and Oregon Station Circular 56, "The Cost of Producing Pork." Practically the entire field is covered in the bulletin on "Finishing Pigs for Market," and the summary table which shows at a glance the relative value of the various common feeds, taking barley as the standard and expressing the value of other feeds on the basis of a percentage of the barley value. For example, with ground barley at 100 percent, whole barley is rated at 88 percent, shorts at 90 percent, bran at 75 percent, skim milk at 33 percent, raw potatoes at 17 percent, cooked potatoes at 25 percent, turnips at 12 percent, etc. This bulletin is available.

In Station Circular 56 the cost of producing pork is expressed in terms of the amounts of grain, labor, etc., required. It is shown that the cost of producing 100 pounds of finished pork, live weight, including the feed of the sow and of the pig from birth to maturity, comprises the following items: 450 pounds of grain or its equivalent, 7 hours of labor, interest on investment, losses on the sows, housing, boar charges, and incidentals. The total labor and other overhead expenses besides grain normally amounts to about 37 percent of the value of the grain. Hence the cost of 100 pounds of finished pork is figured as being the equivalent of the cost of 616 pounds of grain. There will be actually used only 450 pounds of grain, but the remaining cost is in labor, interest, and other overhead. We therefore find that whenever the price of 100 pounds of pork is more than the price of 616 pounds of grain, pork production is on a satisfactory basis and will probably expand. On the other hand, whenever the price of pork is less than the price of 616 pounds of grain, pork production is on an unprofitable basis, except where an unusual amount of waste material of low cost is available. Market statistics of the last ten years show that on the average the farmer who has been raising barley could have fed his barley to hogs and made slightly more

money than by selling the barley on the open market. On the other hand, the farmer who has purchased grain has nearly always had to pay a higher price for the grain than the price of hogs would justify. This has been particularly true of the corn shipped in from the East and of the barley shipped in from California, and it has even been true where such grain has been purchased wholesale in car-load lots.

Farm sheep. Work with farm sheep for the past biennium has followed somewhat the same line as previous years, but especial attention has been given to the problem of breeding efficiency and the factors affecting it. Much attention has been devoted to the influence of fat upon the breeding efficiency of ewes. While the Station is not ready to base final conclusions on the work of two years, the results are nevertheless very striking in that it has been unable to demonstrate experimentally that fat, even excessive fat, has any detrimental effect upon breeding efficiency. It has been found, however, that fat is the usual consequence of non-breeding. In other words, non-breeding ewes usually become excessively fat; but on the other hand, with ewes known to be breeders no difference has been found between those that were put in fat condition and those that were kept in medium or thin condition. This, however, is contrary to the popular idea, and it is possible that some bad influence resulting from a fat condition may yet be found. It has at any rate been demonstrated that such bad results must be less common than is generally supposed.

Beef cattle and range sheep. Since Union is more advantageously located for work with range sheep and beef cattle than is Corvallis, work with those two lines has been confined to that Station and will be reported under the head of Branch Stations.

DEPARTMENT OF DAIRY HUSBANDRY

FEEDING INVESTIGATIONS

The silage feeding experiments comparing vetch with corn and sunflower silage were brought to a close—three years' tests and results published in Oregon Station Bulletin 194, Oats and Vetch Versus Corn or Sunflowers for Silage. The findings show clearly an advantage for oats and vetch silage considering yield, palatability, cost of production and comparative milk production of cows on the three feeds. As a consequence, the dairy program now includes the recommendation "Use more oats and vetch for silage in Western Oregon."

Satisfactory progress was made in the study of winter rations for dairy heifers; further study is necessary for conclusions.

A new project was started to determine the comparative feeding value of alfalfa grown in the Deschutes Valley and alfalfa grown in Western Oregon. There has been indication that exceptional results in milk production are being secured from alfalfa feeding in some of the irrigated sections. The results of the first year's comparative test indicate difference in feeding value. The investigations will be continued.

Cooperation in animal nutrition and disease investigations. The Dairy department cooperated with the nutrition chemist in studies of

mineral supplements in dairy rations. The results are reported under Agricultural Chemistry.

The department in cooperation with the department of Veterinary Medicine continued the investigations of infectious abortion and sterility. The findings are reported under Veterinary Medicine.

Official testing. Aside from the regular work of official testing, Oregon Station Circular 41, "Official Testing of Dairy Cattle in Oregon," was issued; a mimeographed bulletin dealing with the National and State Class Leaders was issued; and a careful study was made comparing the one-day versus the two-day test period. Thirty complete yearly records were studied in detail for each month of the year. The following conclusions were reached:

(1) Not to exceed 10 percent of the animals varied over 10 pounds fat in any of the comparisons made.

(2) A 10-pound fat variation is close enough for all practical purposes as this preliminary study of 30 indicates the trend to be in a larger group and that the one-day test would be a feasible test.

(3) This study indicated that a further and more extensive study of this question is worthy of careful consideration.

A more complete study covering not less than 1,000 records is suggested.

Dairy bull registration. In the administration of this law, which was passed in 1921 and amended in 1923, about 500 animals are licensed annually. There still is difficulty in getting evidence of violations of the law sufficient for prosecutions.

DEPARTMENT OF POULTRY HUSBANDRY

POULTRY BREEDING

Inheritance of high production. As stated in a previous report, the determining of the fact that high egg-production was inherited has been one of the important findings in the breeding work. The breeding project was started in 1908-09 and the results of that year showed an average production of 86.14 eggs for Barred Plymouth Rocks and 106.88 eggs for White Leghorns. During the first year but one hen laid over 200 eggs. Since the first year egg-production has increased. A great many 200-egg hens have been produced and where the 200-egg hen a few years ago was the outstanding individual, we now have flocks averaging 200 eggs and over and the 300-egg hen is not exceptional.

The results of the Station's breeding work has been given a great deal of publicity which has acted as a stimulus in causing poultrymen to give greater care and attention to breeding. At the present time the Pacific Northwest leads the world in the breeding of high-producing flocks. Male breeding birds have been distributed each year to the farmers of the state and it is undoubtedly true that the farm flocks of Oregon now average higher in egg production than do the flocks of other states.

Having found that high egg-production was inherited, the next step along the line of breeding has been a project to determine the possibility of breeding to extend the profitable laying age of the hen.

Breeding to extend the profitable age of the domestic fowl. At the present time, on the average, it is necessary for poultrymen to discard approximately half of their birds at the end of the first laying year because these birds will not produce profitably for more than one year. Of the half that is kept few will be found profitable if kept during the third year. This condition makes it necessary for poultrymen to replace their flocks completely every three years while at the present time many replace their laying flocks each year.

The replacing of the flock is expensive, and depends also on the success of brooding and rearing. The cost of rearing a pullet to maturity is from one to two dollars. The returns from the carcass when sold after the laying period is about fifty cents. The depreciation, therefore, is considerable.

From these facts it is obvious that if a strain of birds could be bred to contain a high percentage of individuals that would produce profitably over a number of years, and the stock made available to the poultrymen of the state, a great saving would be made possible to both producer and consumer.

The experimental work of the Station has shown, as reported in Oregon Station Bulletin 180, "Egg-Laying Characteristics of the Hen," that on the average, a hen will lay her greatest number of eggs in the first year and a decreasing number in each subsequent year. Further, that these hens which make the best first year records, will, on the average, make the best second and subsequent year records.

Taking 160 eggs as the annual production that must be attained by a hen if she is to be a profitable producer, individuals in the Station flock have been profitable producers for as many as five years, some having laid more than 200 eggs in each year for three years.

The purpose of this experiment, therefore, is to ascertain if it is possible to produce a strain of Barred Plymouth Rocks and a strain of White Leghorns in which at least 50 percent of the individuals can be relied upon to produce profitably for four or more years. Foundation stock for the project was selected from the Station flocks upon the basis of size and weight of body as well as weight of and number of eggs produced. It is required, therefore, that in order to remain in the project, a fowl must not only be of a standard size and weight, but must produce in the first year 225 eggs; in the second year 200; in the third year 175, and in the fourth year 150. The experiment is now in its second year and, while progress can be reported, it is not expected that definite results will be attained until several years of breeding work have been completed.

Laying type. A study of body type, in connection with trap-nest records was made to determine, if possible, if there was any correlation between high egg production and type or conformation. The purpose was to determine whether the costly method of selection by trap-nest could be obviated. A great deal of work has been done in the way of measurements and weighing. Thirteen different repeated caliper measurements have been made of some 700 hens. While all this work has not been completed, that which has, indicates a lack of correlation between type or body conformation and egg production.

Early laying maturity in relation to good laying. A study of our egg records is being continued with the view of throwing additional light on factors influencing production. It has previously been shown from the Station egg records that early laying maturity is characteristic of the good layer. Also that the good layer is, on the average, the late fall layer. The records also indicate that the high-producing hen produces at a higher rate throughout the year than does the poor producer. The late-maturing bird may be one of low vitality. Poultrymen are recommended to cull on the basis of both early and late-laying maturity.

Relative influence of sire and dam on the offspring. The data collected and studied thus far indicate that high production is not inherited from one parent only. The importance of the male bird is emphasized, however, as the easier method of building up the farm flock.

Breed Improvement. Considerable work has been done and data collected on breed characteristics. In the work of breeding to increase production, unless attention is given to selection for various characteristics, there will develop considerable variation. From a preliminary study of the data already collected it is questionable as to how many characters may safely be considered in selecting breeding stock from a practical standpoint.

DEPARTMENT OF VETERINARY MEDICINE

PROJECT INVESTIGATIONS

Infectious abortion caused by *B. abortus* (Bang).

Methods of spread of the disease. These studies have been continued and the data accumulated are in accord with the statements in previous reports.

Duration of infection. Animals infected as long as seven years ago continue to carry the disease. It becomes increasingly evident that under ordinary dairy conditions there are not very many recoveries from the disease.

Establishment of abortion-free herds from abortion-infected herds. This phase of the work has made satisfactory progress. In the College herd there are now more abortion-free females than there were both infected and free females in the herd when it was first separated into two groups. Success has been attained in other herds.

Retained fetal membranes. Accurate records have been kept of 55 retained fetal membranes that were removed manually. Results have been very satisfactory. No deaths have occurred and over 80 percent of the cows have bred again. It has been stated by some of the stations that the removal of membranes was not a satisfactory and scientific procedure. These statements prompted the work which is being done here. This will be continued until the series reaches at least 100.

Sterility in bulls. Considerable data have been collected on the microscopic examination of the semen. These have been checked with the breeding ability of the animals. A satisfactory technique for lab-

oratory study has been worked out. It was not possible to do field work this year and results at present cover too small a number of animals to reach any conclusions concerning the results of treatments. With another year of work this problem should be far enough advanced to reach some conclusions.

Sterility in cows. Very little work has been done on this problem. Limited data indicate that disturbances of the oviducts are probably more common than has been heretofore supposed. Methods of treatment have been uniformly unsatisfactory.

Miscellaneous Studies

Coccidiosis in poultry. This continues to be one of the serious problems of the poultrymen. The hydrochloric acid treatment as reported last year has seemed to give some results. There has been no opportunity to run controlled experiments, however.

Gape worms in pheasants. These parasites were found for the first time in Oregon. They were causing a very serious epidemic. The difficulty seems to have responded to the method of handling that was outlined. This consisted in getting the birds on new ground, thoroughly spraying all the premises with creolin solution, and not turning the young birds out until the dew was off and the earthworms had stopped crawling on the surface of the ground.

Lung worms in silver-black foxes. There were several calls for help from one of the larger fox ranches in the state. Autopsies revealed that the foxes were rather heavily infested with lung worms. This parasite had not been reported in Oregon before. It had probably been imported from Canada. No work other than diagnosis was attempted.

DEPARTMENT OF FARM CROPS

FORAGE AND SEED PLANTS

The forage investigations carried on cooperatively with the United States Department of Agriculture have resulted in standardized recommendations as to varieties, time, rate, and method of seeding vetches, alfalfa, clover, grasses, rape, kale, and miscellaneous forage plants. The work has resulted in the establishing of a few varieties of certain forages, and of replacing others by better kinds.

VETCHES AND RELATED PLANTS

Varietal trials. The variety trials, including the regular plot trials and the nursery row trials, have been continued with the more important vetches and new ones as they have been introduced. The varieties that have been proved most economically feasible are Common vetch, *Vicia sativa,* Hungarian vetch, *Vicia pannonica,* Woolly Podded vetch, *Vicia dasycarpa,* Hairy, winter, Russian or sand vetch, *Vicia villosa,* Purple vetch, *Vicia atropurpurea,* Pearl vetch, a white seeded type of *Vicia sativa,* Monantha vetch, *Vicia monantha,* and two related plants, horse-beans, *Vicia faba,* and Tangier peas, *Lathyrus tingitanus.*

Each of these are valuable for certain sections of the state for one or more uses such as hay, silage, green manure, and seed.

Forage vetches. Common vetch is the best hay and silage vetch for the fairly well drained, heavy upland soil, for fall planting. It also is used to some extent for early spring planting, but is probably not as good as Pearl vetch for this purpose. Fall planting of Common vetch is the best general practice, but if spring planting must be done Pearl vetch is somewhat better for that season.

Hungarian vetch is the best vetch for the lands that are rather low, flat, and not very well drained. This vetch also thrives better on the more acid soils of the Willamette Valley. It has proved a very good yielder of hay and silage, and the quality of the seed is very good. It is somewhat finer stemmed than Common vetch, and appears to retain its leaves better. In addition to its adaptability to rather cold, wet, sour soils it is also resistant to aphid attack, and is more winter hardy than the Common vetch. The acreage of Hungarian vetch has increased from sixty or seventy acres, planted in the fall of 1921, to about fifteen thousand in 1924.

Woolly Podded vetch is hardy, makes a fair quality of forage, stands more acidity in the soil, and is more easily inoculated in the Coast Region than either Common or Hungarian vetch. It is also more winter resistant than either one. It offers promise as a pasture vetch on some of the rather dry hill lands of the Willamette Valley and of Southern Oregon.

Purple vetch is being used as a spring planted hay, green feed, and silage crop in some sections along the Coast.

Tangier peas in sections where the winter conditions are not too severe offer promise as silage and green manure. They have been somewhat intermittent in their productiveness. They are not so hardy as Common vetch or Hungarian vetch, being similar in this respect to Purple vetch. They, therefore, seem best suited to sections of southwestern Oregon where the climate is more mild than the average Willamette Valley climate. They make an excellent yield of forage for silage purposes, and the silage is of good quality. There is some possibility for them with very early spring planting on rich soil, but for fall planting they seem best adapted to southwestern Oregon.

Seed vetches. Purple vetch, the adaptability of which was worked out by the Experiment Station, has been grown with intermittent success in the Willamette Valley, and with more consistent success in the southwest Coast districts and in Douglas county. Purple vetch is not quite winter resistant enough for some soils in the Willamette Valley. Where it survives the winter, the plantings that are made alone are more productive of seed, but plantings made with oats seem to withstand winter conditions better than plantings made alone. The milder winters in Coos and Douglas counties are more favorable to the crop than the conditions in the vicinity of Corvallis.

Both Hairy and Woolly Podded vetch are hardy, and have produced good seed yields in the experimental work. Hairy vetch, which for the importation period of five years ending June 30, 1925, has been brought into the United States at an average annual amount of 2,042,000 pounds,

has proved a very good commercial seed crop. Plantings are increasing, and growers are becoming familiar with the market demand for the crop.

Hungarian vetch is increasing in acreage in Western Oregon, and some interest is being shown in it in California. Of all the vetches experimented with, it has the best seed habits, and tends to shatter less than the others. Common vetch seed is used rather extensively in Oregon and California.

Tangier peas are rather productive as a seed crop, but owing to winter killing in the Willamette Valley, the greatest possibility in this line seems to be in the southwestern Oregon Coast section. The market for Tangier pea seed is not established.

Horse-beans. The horse-bean experiments are being continued, and they show promise as a supporting crop in connection with vetches for silage purposes. With the development of better sowing and harvesting methods, the better varieties may become useful, not only in silage combinations, but as a grain crop. They are best suited to well-drained, mellow, and reasonably rich soils. Inoculation is usually necessary.

Cultural trials. These trials indicate that where winter killing is not a serious factor it is usually best to grow Purple vetch, Tangier peas, Hungarian vetch, Hairy vetch, and Woolly Podded vetch alone, or without a supporting or companion crop. Hungarian, Common, Hairy, and Woolly Podded vetches are sufficiently hardy that there need be no exception from this. In areas where there is a little more danger of winter killing the planting of Purple vetch and Tangier peas with a companion crop of oats is generally a better practice. Sixty to eighty pounds of Common, Purple, or Hungarian vetch is a very satisfactory rate of sowing for seed purposes, and a similar amount, with forty pounds of oats, meets the requirements for other purposes. Spring planting is not usually so good with Common vetch, Hungarian vetch, Hairy or Woolly Podded vetch, and if done at all it must be early, usually before March 1. Work with Purple vetch, Pearl vetch, Monantha vetch and Tangier peas indicates possibilities for spring planting.

Vetch rotation. The growing of vetch in rotation with other crops has proved good for some other crops, in that yields of wheat have increased. There has been a slight increase in the yield of corn and an increase from the original yield of oats. Yields of potatoes are declining, the rotation being too short for that crop. Disease is probably responsible for a large part of this loss. Vetch grown continuously for hay purposes is holding up in yield. The yield of seed appears to decline, although there are not enough plots, and the work has not been carried on long enough to make conclusions positive. Seasonal rainfall seems responsible for some of the variation. There appears to be some increase in weeds in the continuous planting plots.

Work with the perennial vetches is continuing, although none have proved promising to date.

Breeding work. Pollination studies with vetches indicate that they are largely self-fertile. Hybridization work has not been profitable. Better results have been secured by making selections from the field.

Field peas. A planting of Austrian winter field peas, made in the fall of 1923, survived the winter and made a remarkable growth. It is deemed worthy of continuing the experimentation on a larger scale.

RED CLOVER

Varietal trials. Forty-four lots of red clover secured from Oregon, the North Central States, Chile, North Europe, Italy, and a few other places were grown in plots. Data were secured on hay yields, longevity, disease resistance, and plant characteristics of the different lots. The South European lots are not so desirable as most of the others. It is the plan to continue testing, and to multiply the better lots for distribution. It is thought that by this method greater productiveness for Oregon may be secured, and that greater hardiness for our seed surplus will improve our market in the Eastern States.

Cultural trials. Study of time and manner of sowing red clover has been continued. Less than 12 pounds an acre of clover seed usually reduces the stand. April or May seeding of clover alone is satisfactory and desirable on run-down land, or where it is difficult to secure a stand. Under good clover-growing conditions, February sowing with fall-sown cereals usually results in a good stand, the best being secured with barley or wheat. With this method a subsequent summer of dry weather, especially on the heavier types, may result in death of the plants.

Fertilizer results on securing a stand. Spring application of land-plaster, sulfur, and lime, as compared with no treatment gave good results for the use of land-plaster, although no results in securing a better stand were noted following the use of either lime or sulfur.

Clover breeding

Selections have been and are being made toward the development of (1) Red clover with short tubed corolla that honey bees may cause tripping. (2) A variety resistant to stem-rot. (3) Varieties suited to soils of different degrees of acidity and moisture. (4) Longer lived, high-yielding strains.

ZIGZAG CLOVER

Zigzag clover is a perennial grown to some extent in Germany, Russia, and Siberia. After a number of years' efforts to secure this clover a small quantity was obtained. Zigzag clover is a true perennial and spreads by underground roots. While appearing promising from the forage point of view it presents some very serious seed problems. It blooms very profusely but sets very little seed.

SWEET CLOVER

Yellow and white flowered annual and biennial varieties of sweet clover have been tried out. All of them are very susceptible to the disease of stem-rot, and none are proving as valuable for Western Oregon as the Red clover, Alsike clover, or vetch. Selections of stem-rot-resistant strains have been made and are being tested.

BUR CLOVER

Bur clover is being tried in dry hill pastures, and is proving palatable, and able to reseed and maintain itself under rather heavily pastured conditions. It offers great promise for fall, winter, and spring pasture

in Western Oregon generally, and especially in Southern and southwestern Oregon.

Alfalfa

Varieties. Grimm alfalfa is well suited to the river-bottom lands, and succeeds better than other varieties or most strains of common alfalfa. Variety trials indicate that Grimm is very resistant to stem-rot.

Cultivation. The alfalfa cultivation trial shows that late cultivation which breaks off buds, tends to retard crop development. The uncultivated plots, which are becoming grassy, give a greater yield of grass hay than the cultivated plots, but the percentage of foreign material in the uncultivated plots is very great. It appears that the best practice is to cultivate early before the buds begin development.

SOY-BEANS

The soy-bean work is being continued. Inoculation is necessary for reasonable success. Manchu, Mandarin, Black Eyebrow, and Ito San seem best for forage; Ogemaw and Chernie are best for seed. The crop does not offer great promise because of the lateness of maturing and difficulty of harvesting in wet years.

MISCELLANEOUS LEGUMES

Ladino clover. This giant form of white clover is durable and is making a rank pasture growth. On the two soil types, both heavy and not very well drained, its stand is thickening. Established seedings produce well for at least four or five years. The crop offers promise for pasture and for seed.

A number of other leguminous plants are in trials, but their value is not sufficiently established to warrant special reports.

GRASSES

Grasses are being grown to demonstrate their usefulness for hay, pasture, lawn, golf course and soil binding purposes, as well as their possibilities and productiveness as seed crops.

Hay grasses. As in the previous reports, timothy and the rye-grasses, both English and Italian, are giving good results in moderately heavy and not very well drained soils, where a short-lived grass is desired. Reed canary-grass is being cut for hay under somewhat moist conditions, and is also showing some promise on soils that are not subirrigated or wet. The hay is rather coarse.

Seed production. Various grasses tried for seed production continue to give satisfactory yields. Kentucky blue-grass through six years has varied from 200 to 256 pounds an acre, timothy from 345 to 470 pounds of seed an acre, English rye-grass from 420 to 615 pounds an acre, orchard-grass 240 to 420 pounds, tall oat-grass 320 to 370 pounds, meadow fescue 190 to 390 pounds an acre, and there may be a possibility with some of the bent-grasses and meadow-foxtail. The growing of grass seed is rapidly becoming an important industry in Western Oregon. The principal production at this time is with the rye-grasses.

Pasture mixtures. Continued results with the pasture mixture planted on the Calvin Ingle Hill, and another planting on a very badly worn, poorly drained, and farmed-out piece of land, show that for the hill lands rye-grass, orchard-grass, tall oat-grass, meadow-fescue, Kentucky blue-grass, bur clover, red clover, and white clover are very good. On the rather heavy and somewhat flat land at the base of a foothill the rye-grass, timothy, and red-top gave good results, but the outstanding thing, considering survival and palatability, was meadow-foxtail.

The Station work is being used as a basis for making recommendations for numerous pasture mixtures.

SPECIAL GRASSES

Creeping bent-grass. This grass is grown primarily for seed production, the seed being used on golf courses, lawns, and other places desiring a dense, fine turf. Many problems arise in connection with the identification of these bent grasses as there are numerous strains. These are being studied from the standpoint of plant characteristics, turf value, and seed production. Experiment Station representatives are keeping in close touch with the commercial seed developments in the Coast region of Oregon.

Reed canary-grass. This grass is especially suited to moist, rich soil. It is hardy, long-lived, and a heavy forage producer. Seed is high priced and difficult to harvest because of early shattering. Selection of strains to overcome this development is being made. Reed canary-grass is primarily a marsh-land pasture grass.

Harding grass. This grass has been exploited in Oregon to some extent, and the type exploited in the state has not been a desirable one. There are two definite types of Harding grass. The type generally sold in Oregon is a bulbous type, and is inferior in quality, short lived, and a small yielder. Another type in trial shows promise of being longer lived and a better forage plant. It is being increased and more extensively tested.

Miscellaneous grasses. A hardy strain of Bermuda grass, bulbous blue-grass, bulbous meadow oat-grass, and tussock-grass are being tested. Numerous grasses which have been advocated have been tried and proved of no value for Oregon conditions.

Grass improvement. Selections of grasses have been made and are being tested to insure higher yielding qualities, disease resistance, improved seeding habits, and other desirable characteristics. Work is being carried out along this line with timothy, blue-grass, meadow fescue, tall fescue, Reed canary-grass, Harding grass, the rye-grasses, and bent-grass.

RAPE

Seed production. True Dwarf Essex rape has been grown to supply pure seed for seed-production purposes. The crop produces up to 1,000 pounds of seed an acre. Demand for pure seed is good and it offers promise as a cash crop.

MISCELLANEOUS EXPERIMENTS

Freaks, fakes, and crops unsuited to our conditions. Numerous plants are exploited by individuals and organizations claiming remarkable forage value and many other useful points. Many of these highly advertised plants have been tried out and proved not worth while for Oregon agriculture. Among them may be listed Eureka clover, or Giant knotweed, Rhodes grass, Vasey grass, and Napier grass. The list also includes Kudzu, KiKiyu, Smilo grass, Serredella, and Lespedeza. Some of these are valuable, of course, in some other sections of the United States, but to date none of them are of any value in any section of Oregon.

ROOT TRIALS

Mangels. Variety trials with mangels indicate that this crop is excellent for winter stock feed. Danish Sludstrup, Half-Sugar and Mammoth Long Red have given largest yields. The yields vary from 14 to 20 tons an acre.

Turnips and rutabagas. The production of turnips and rutabagas for stock feed has not proved successful because of dry summer conditions and heavy damage by root maggots.

Carrots. Carrots grew successfully, but the yields are too low to be profitable, except for special purposes. Chantenay was the best variety.

Sugar-beets. A trial of sugar-beets was planted in 1924, following a revival of interest in that crop. The early growth was very promising.

Artichokes. A new artichoke, the Mammoth White French, was grown for the first time in 1924. It shows much promise. The tubers are smooth and produce in hills similar to potatoes. Its keeping qualities seem to be better than that of the old type artichoke.

CEREAL INVESTIGATIONS

Winter Wheat

Thirty-one new selections and varieties from the nursery and four new spring varieties; namely, Jenkin, Federation, Major, and Onas, have been included in the winter wheat varietal trials. Of these Jenkin has given very promising results. It is a brown-chaffed, white-kerneled club wheat. It has a stiff straw that does not shatter badly. White winter and Rink have continued to give high yields. Federation has not given good results from fall sowing.

Cultural and tillage trials. These trials, started in the fall of 1921, are for the purpose of determining the best method and time of preparing the seed-bed for fall and spring wheat, and the best time and rate of sowing for each.

The results to date are very much in favor of the fall sowing.

Eight-inch plowing has generally given better yields than the five-inch plowing, and apparently as good yields as the eleven-inch depth.

Disking before plowing has not resulted in higher yields except in the case of late spring plowing. It has tended to decrease yields in the case of fall plowing after the ground is wet.

Indications are that two bushels an acre is the best rate of sowing for fall and spring wheat.

Breeding and nursery work. All of the commercial varieties of wheat of the United States showing any promise in Western Oregon have been carried in replicated rod rows. Large numbers of selections from the commonly grown Willamette Valley varieties and other varieties in Eastern Oregon, as well as smut-resistant selections and hybrids, have been included in the nursery. Some very attractive and promising selections have been obtained. Increased attention has been given barley and oat breeding, and some work has been carried out in connection with selection of rye. This work has been transferred to E. N. Bressman.

Spring Wheat

Varietal trials. Seventeen spring wheat varieties have been included in the trial. Several of them are good. Huston, on the heavier soils, and Federation and Jenkin, on the more mellow soils, are among the best varieties.

Cultural trials. While this work has been under way but a short time, the results are very pronounced in favor of early planting of spring grains. These early plantings are substantially better than the late ones, although not so good as fall planting at the right time.

Oats

Varietal trials. The oat varietal trial has been extended. An unidentified variety called No. 2 has exceeded others in yield. Senator, an oat of very poor quality, has been next, and Victory, a very superior oat, has been third. The Station is recommending Victory and Three Grain, both good yielding varieties of which seed is available, and both of substantially better quality than Senator.

Barley

Varietal trials. Three fall and four spring varieties were in the trial. All of the fall varieties were winter-killed in 1922. There is need of a more winter-hardy type of barley for fall planting. Hannchen has continued to give satisfactory results for spring use.

Seed Flax

Varietal trial. A varietal trial including six varieties of seed flax was started in the spring of 1924. A planting of the wheat-flax mixture, a practice that is being followed to some extent in the North Central States, was made. It is planned to expand this experiment.

MISCELLANEOUS EXPERIMENTS

Continued seed treatment experiments, including copper carbonate, formaldehyde, and some of the organic mercury compounds, have been carried out. So far copper carbonate appears most successful.

CORN EXPERIMENTS

Work with corn varietal trial was resumed in the spring of 1924. This work has been assigned to E. N. Bressman.

POTATO EXPERIMENTS

Varietal trials. The varietal trial was continued, Burbanks giving excellent results. Generally speaking, the variety freest from disease is the one that gives the highest yields. The introduction of a new, quite disease-free strain of potatoes into the stock that has been grown in the varietal trial for some years and become diseased usually shows the introduced variety to be best. Where comparable yields from seed of comparable quality can be obtained, however, the Burbank has been a very good yielder, and has generally been better than the Netted Gem.

Cultural trials

Type of seed piece. Continued trials with the "whole blossom-end piece" and whole potatoes continue to demonstrate the superiority of the piece carrying the bud-eye cluster. This blossom-end or seed-end when split in cutting, as is the usual practice, is not nearly so productive as when it is cut off in one piece. It appears that this piece produces the strongest stalks, and the greatest number of stalks per hill. There is less difference where large seed pieces carrying a large number of eyes are compared with the whole blossom-end piece, but in general the blossom-end piece is the most productive piece.

Size of piece. Other things being equal, the larger seed pieces usually produce the biggest yields. They produce more stalks per hill, and a greater yield of potatoes. Without doubt, on the richer soils where moisture conditions are good, large seed pieces are practicable. Considering seed cost and yields, the 1½-ounce pieces seem particularly good for average soil conditions and average rates of planting.

Spacing experiments. In general the close planting, as 12 to 13 inches apart, has been more productive than medium or wider planting, going up to 18 to 20 inches apart. This is consistent with the size-of-piece results, as the spacing that tends to produce a large number of stalks per acre tends to produce the biggest yields. Twenty bushels of seed an acre cut into 1-, 2-, and 3-ounce pieces continued to show larger yields for the smaller pieces planted closely.

Time of planting. Yields continue to be favorable for early rather than late planting.

Depth of planting. Medium planting, as 5 inches, continued to give better results than shallow (3½ inches) or deep planting (7 inches).

Treatment of cut seed. Land-plaster applied to the cut seed consistently gave increases in yields. In some years these are quite small, but represent a profitable practice.

Potato fertilizers. Readily soluble fertilizers and some not so soluble, coming in direct contact with the seed pieces, kill the eyes. Good results are secured with nitrogenous fertilizers, with sulfate of ammonia apparently somewhat better than nitrate of soda.

Storage Experiments

These experiments, because of lack of storage facilities, had to be discontinued.

MISCELLANEOUS SERVICE

Considerable investigation has been carried on in connection with the better marketing of some of the seed crops. This has been done through careful study of statistical data, correspondence and conference with experts qualified along those lines.

Four thousand five hundred and eighty-six tests were made on 3,303 samples of seed received for testing during the two years. The Experiment Station cooperating with the United States Seed Laboratory of the Bureau of Plant Industry does this work. This service points out to many seed dealers, county agents, and farmers the good lots of seed as well as those undesirable for sowing purposes.

Staff members of the Farm Crops department put on extensive exhibits at the State Fair and at the International Livestock Show.

DEPARTMENT OF SOILS

The development and preservation of the soil and water resources of Oregon constitute our greatest problem. Oregon soil investigations are conducted under a special biennial appropriation, amounting only to $7,500 a year, which must be made to care for soil surveys, drainage, irrigation, and soil fertility investigations. All field and laboratory experiments of the Soils department at Corvallis are maintained by this fund. It must also care for field agents and the work on the sulfur experiment field at Medford, and the alkali-land experiment field at Vale. About $2,000 a year is required of this fund to carry on detailed soil surveys according to agreement with the U. S. Bureau of Soils. Nearly $1,000 a year is needed for publications. A similar amount is required for feasibility surveys of proposed reclamation projects. Also, some twenty cooperative field fertilizer experiments with different soil types are maintained.

SOIL FERTILITY INVESTIGATIONS

Fertility rotation. The thirty-two rotations started on 92 plots in 1915 are being maintained and are giving more and more striking differences. Where manure, clover, or lime has been followed with grain the yield of winter barley is about 60 bushels per acre, while the yields on plots continuously cropped to grain is about 25 bushels per acre. In the irrigation field are the oldest plots in the state that show the effect of constructive soil treatment. They cover a period of four 4-year rotations. In this field four 3-year rotations have also been carried out and have just about doubled the yield of beans following clover and grain in rotation as compared to beans being grown continuously. The increase from crop rotation is almost clear profit. The value of rotation and fertility experiments increases with the duration of an experiment. These trials should be on a permanent basis.

Fertilizer experiments. Fairly complete fertilizer trials are being continued on a score of different soil types in the state. A new syste-

matic experiment has been established for Willamette silty clay loam on the Home Station, with three series of plots containing 25 plots each, one series being cropped to grain, another series to clover, and the third to corn each year. Additional cooperative fertilizer experiments are needed on a few other important soil types in the Valley, and should be started promptly. It is estimated that, at least $500,000 is now expended in Oregon annually for fertilizers, and that one-third of this amount is wasted by improper use. On some of the older trials none of the treatments employed proved profitable.

Successful use of fertilizers depends on their cost and value of crop increase secured from them. Certain fertilizers for given soils have proved very profitable, and their use as a farm practice is recommended.

Phosphorus. Soluble phosphates have continued to prove beneficial and profitable on red-hill soils of Western Oregon, on the worn, grained land of the Valley floor, and on the creek bottoms of the lower Willamette Valley. It is now being used commercially on about 25,000 acres and its use is being extended. Fertilizer experiments and soil analyses indicate that it will be helpful to about half a million acres of red hill land in the more humid sections of this state. Certain acid marsh soils continue to show benefit from application of available phosphate. Granitic soils and some bottom soils of Southern Oregon respond well to phosphate applications. Sedimentary soils of the lake region are below average in phosphorus, as shown by analyses in connection with feasibility surveys. Fertilizer experiments indicate that phosphate will be of value for reinforcing manure in that section.

Studies on the availability and utilization of phosphorus in soils of high iron content are being reported in bulletin form. These studies made by Professor Ruzek are described by him as follows: "Acid phosphate alone and in combination with barnyard manure gave larger increases in yield than rock phosphate alone or rock phosphate and manure. Lime did not aid in making rock phosphate more available but organic matter and sulfur did. This was shown by increased yields and by analysis for soluble phosphate. Rock phosphate, when composted with sulfur and manure, gave a large increase of soluble phosphate."

Sulfur. The Medford experiment field, started by Reimer in 1914, is still being maintained by the Soils department, to learn the duration of the sulfur treatment and accumulative effects of applications of sulfur in long-time experiments. Additional plots have been arranged to study the value of sulfur, phosphorus, and manure, for making available phosphate and sulfate from raw rock phosphate, and elemental ground sulfur. Irrigation experiments have been added on this field which must be maintained for at least another season. It is of great value in showing the ultimate effect of sulfur, and in supplying material for laboratory studies. It is becoming evident that phosphorus, as well as sulfur, will be needed to be supplied to this Antelope clay adobe soil.

Most of the alfalfa-producing soils of the state have been tested out and found to respond to sulfur applications. Studies have been made of the sulfur content of soils and crops, drainage and irrigation or rain water, and of the soil solution. Some red hill soils in Western Oregon have given good increases from sulfur applications. Lump sulfur ground once and passed through a 10-mesh sieve has been found to oxidize sufficiently rapidly to meet the plant needs.

A special study has been made of the oxidation of sulfur and solubility of soil minerals. A study was conducted the past winter on Deschutes sandy loam and Willamette silt loam to which sulfur was applied in different amounts and composted. Doctor R. E. Stephenson made analyses of these composts and found "that sulfur had a marked effect on the solubility of several elements of plant food. An application of 100 pounds of sulfur increased the amount of water-soluble calcium (lime) nearly 50 percent on both soils. Heavier applications gave still larger increases. This increase may be of special benefit with such crops as alfalfa and clover which are heavy lime feeders. Sulfur also increased the amount of soluble potassium in both soils, the increase being nearly 40 percent for the Deschutes soil. Sulfur reduced the soluble phosphorus because of the very large amount of soluble calcium which precipitated the phosphoric acid. The oxidation of sulfur to sulfuric acid tends to increase soil acidity in the humid soils, and to improve reaction in the arid soils."

Fineness of grinding sulfur. During the past few months a question has developed as to how fine sulfur will need to be ground. Under the direction of Professor Ruzek, two advanced students, Messrs. Lance and Higby, started a study of the rate at which sulfur became available when composted with Deschutes sandy loam soil, using different brands of sulfur, and sulfur ground to different degrees of fineness. During the past summer months, these studies were continued by Doctor Stephenson, using crude sand sulfur and flowers of sulfur, and crude sand sulfur separates individually. The rate of oxidation for sulfur was tested at regular periods up to five and one-half months. Doctor Stephenson reports: "The finest ground separates oxidized most rapidly. Crude sand sulfur, a mixture of various sizes, oxidized more rapidly than did the fine flour sulfur, although there is no evident reason for this difference. All the sulfur separates were considerably oxidized after a month. At the end of the study the sand sulfur was 74% oxidized, compared to 86% of the hundred-mesh separates, 73% for the eighty-mesh separates, and 23% for the flour of sulfur. It appears unnecessary to grind crude lump sulfur to extreme fineness for use on soils. Use of crude sand sulfur may reduce the original cost, and it is possible that this treatment will be effective for a longer time because of the coarser material. Ten-mesh sulfur was only 4% oxidized, and coarser than ten-mesh, only 1½% oxidized at the end of the study."

Potash. Potash has doubled the onion yields on Lake Labish, where soil analyses showed the soil to contain only 8,000 pounds of potash in a plowed surface of an acre, whereas most of the soils of the Valley floor contain 25,000 to 40,000 pounds of potash in the plowed surface of an acre. This almost inexhaustible supply can be liberated by the use of farm manure and clover in rotation will help liberate sufficient potash for farm needs. Sulfur may also help bring potash into solution.

Residual soils in the Deschutes Valley are somewhat below average in this element, and complete fertilizer experiments extending over several seasons show that potassium sulfate will give good profit applied to such crops as potatoes. Sulfur in sulfate of potash is of value for legumes on this land. Application of one pound per square rod is found to give less economical returns than one-half pound per square rod.

Nitrogen. The nitrogen content of Willamette Valley soils has been found to run less than half that of typical corn-belt land. Nitrate fertilizers continue to prove helpful where legume sod could not be secured for growing cash crops. The use of legumes is still regarded as a more constructive and profitable treatment than the application of a commercial nitrate, except as a starter, wherever rainfall or irrigation makes it possible to secure this element from the inexhaustible supply of the air by means of nitrogen-fixing bacteria and legumes. A little gypsum appears to aid nitrification early in the season after the winter rains have removed available nitrogen. Marked increases have been secured on unthrifty grain, on rather wet land early in the spring, by application of nitrates or ammonium sulfate. Just at this season the plant suffers for lack of available nitrate, due to the cool, winter season and leaching, and the fact that nitrates do not have time to develop until after a week or ten days of clear warm weather.

Soil acidity and liming. In acidity surveys being continued in connection with the soil surveys of the Willamette Valley, the naturally-drained soils of the Valley floor and stream bottoms show moderate lime requirements, one-half to one and one-half tons an acre. Wet soils after drainage need from one to two tons, according to acidity, and hill lands have a lime requirement, say one and one-half to three tons.

A new liming experiment has been initiated on Willamette silty clay loam on the Home Station, to study the effect of rate and form of application, and the value of lime used alone and in combination with manure and phosphate. Ground limestone from the State Lime Plant has been effective in correcting acidity in these plots, and is causing increases in yields. Lime may be expected to benefit soils known to be acid, or to be of medium acidity and heavy texture, particularly where such legumes as alfalfa or clover are to be grown. The increased yield on the Home Station where lime is employed in connection with a rotation of grain, clover, and corn has caused an increase in crop value for the rotation of $15.30, from a one and one-half ton application. On white land lime has given .45 ton increase; lime and manure .9 ton increase, with alsike clover at one cutting, following tile drainage. The use of ground limestone on acid soils is fundamentally sound. Heavy rainfall and the removal of calcium by crops tends to deplete the soil of lime, increase acidity and make it more difficult to secure a stand of clover. Application of lime then becomes essential to the establishment of a permanent economical system of agriculture, which calls for growing of clover in rotations.

Organic manure. The project to determine the supply and best method of increasing and maintaining the organic matter in Oregon soils has been continued. Composting straw with ammonium sulfate and water is a promising method of reducing straw promptly to a humus state or active state, for fertilizer, and is being given consideration.

The use, care and value of manure has been made a subject of special study. In the irrigation field a profit of from $2.50 to $10.00 a ton has been realized from manure. Alfalfa has been found the best customer for manure for field crops at the Umatilla Branch Experiment Station, where $2.50 a ton has been realized from light applications. Crop residues have been employed in connection with these experiments

and as much as one-ton increase in grass and clover hay has been secured from the application of straw.

Sixteen plots in the irrigation field devoted to a manuring rotation have gone through one rotation. Manure and lime this year (1924) gave a yield of 72⅔ bushels of wheat an acre, as against 60 bushels for untreated plots.

An experiment was planned and initiated to study the losses in mineral nutrients and organic matter, where manure was exposed to the heavy winter weather of this climate. Galvanized tanks were filled with fresh horse manure, to which oat straw was added as an absorbent, and exposed to the weather. One of the tanks was untreated, a second untreated but protected from rainfall, and others received absorbent in the form of rock phosphate and sulfur, superphosphate, calcium sulfate, or soil. Leachings were measured and samples collected for analysis at regular intervals under direction of Professor Ruzek. The period of exposure was twelve months. Professor Ruzek reports: "Where straw or other absorbents were used, the total loss of plant food was increased, but the percentage loss was decreased. Composts protected from leaching showed the lowest losses, and this, undoubtedly, is the most practical means of preventing losses. Straw increased losses in nitrogen, calcium sulfate and superphosphate cut down nitrogen losses, and a larger amount of phosphate was lost from leaching where superphosphate was used than where rock phosphate was used. Untreated manure showed the greatest total loss. The loss in dry matter during twelve months storage ranged from 35 to 53 percent."

Material from these composts is to be employed in sand pot cultures for vegetative tests in the greenhouse.

SOIL SURVEYS

In cooperation with the U. S. Bureau of soils field work for the detailed soil survey of Linn county has been completed and the report prepared. During the past season one surveying party has worked in Lane county and some four months' work remains to complete the mapping of that county. Published soil reports have been received from the Josephine county soil survey and the Benton county soil survey. Reports have been prepared covering Clackamas and Polk counties. These reports are now in press.

With the completion of Lane county, there will have been a detailed survey covering 5,293,615 acres, including all Willamette Valley counties, except Marion, outside the National forests. Josephine county was mapped in detail in 1919, making a total of 5,783,215 acres mapped in detail. It may be possible to start one field party on the detailed survey of Marion county the coming year. A soil map poster of Multnomah county was prepared.

Official samples of each soil type in each county have been collected and submitted to the station chemist for analyses. These analyses have been completed up to Linn county. These surveys are recorded on a map with a scale of one inch to the mile, the soil types being represented in different colors. All important landmarks have been shown on the base map used. From these maps a farmer can tell what type or types of soil cover his farm. From the analysis he can learn their average compo-

sition, and the field fertilizer experiments which follow on the main soil type give information as to the fundamentals for development of permanently profitable systems of soil management for these lands. These surveys serve as invoice of agricultural resources and as a basis for soil investigations.

Feasibility surveys. Preliminary feasibility soil and agricultural surveys have been made during the biennium, of six irrigation projects, including 301,300 acres and of two drainage projects, including 1,500 acres. A total of nearly 3½ million acres has been thus examined during the past few years, and 1¼ million of this has been organized for reclamation. Four of these projects were examined for the U. S. Reclamation Service the past summer; namely, Baker, Vale, Owyhee, and the north unit of the Deschutes project. The investment involved in the four is nearly $32,000,000. These feasibility surveys establish the merits of reclamation for a feasible project, and help to cull out less desirable land, and shape the projects up in the most desirable way from an agricultural and economic standpoint. One of the drainage projects examined has been constructed and the other partly constructed.

Fourteen large farms in Marion county were examined for the State Board of Control as possible sites for the new Boys' Training School. The total area was some 5,000 acres, and detailed soil maps were made of each farm.

Assistance has been given in designing tile systems and individual pumping plants and irrigation systems, as Extension work, but based on Station results.

Drainage and improvement of wet land. (1) A study of the water-table and outflow on a tiled white land field, and the effect of clover, lime, and manure in aiding percolation in this field and in drainage gauges or lysimeter tanks similarly treated is being continued, lime and manure proving very beneficial for increasing the efficiency of tiling and in improvement of tiled white land. This drainage field where winter grain failed before tiling yielded 65 bushels of winter barley the past season.

(2) Proper depth, capacity, and distance apart for tile lines as judged by water-table outflow and yields are being studied in cooperation with the Branch Experiment Station at Astoria.

(3) A third drainage experiment is located on a ten-acre tract near Vale, in Malheur county, where an outlet drain has been sluiced at a very low cost, and the land has been cleared for irrigation and divided into plots to observe the value of different treatments which will aid in laundering out the alkali, and restoring favorable structure to the land. Sulfur and manure have made it possible to raise a fair crop of rye and get a good stand of sweet clover on certain plots, while copious irrigation in the native brush land has brought in a good growth of tame grasses seeded on this land, and effected partial reclamation. The sluicing method of drainage was developed in connection with this work and has saved the Southeast Unit Drainage District alone $20,000 in the construction of drains. A progress report has just been issued on this work in bulletin form.

(4) A chemical study of leachings from drainage tanks was continued the past season, analyses being made by Doctor R. E. Stephenson. Doctor Stephenson reports:

"Results show applications of manure have increased loss of potassium due, no doubt, to increased amount of water soluble potassium. There continues to be a rather heavy loss of calcium. The lime plots, however, seem to have been leached until there is very little more loss of calcium than where no lime was used. There has been appreciable loss of phosphorus, and rather heavy loss of sulfate, the latter loss being increased by application of manure. Loss of nitrate has been greater where manure was used. Both lime and manure have been effective in increasing permeability of the soil, both in white land and Willamette silty clay loam. It is quite important to have a growing crop or special cover crop on the soil in the early winter season when the losses appear to be heaviest. The growth will retain nutrients, and prevent, in a large measure, their loss."

Duty-of-water investigations. Duty-of-water investigations have been continued on the experiment fields at Corvallis, Hermiston, and Burns. Due to lack of funds, such trials were dropped in Deschutes and Rogue River valleys, while a little duty-of-water work has been added near Vale.

Supplemental irrigation in the Willamette Valley is becoming of more importance in connection with intensive truck or green feed. Irrigation has saved the stand of red clover during recent dry years on the irrigation experiment field at the Home Station and has also made excellent late-season pasture possible. Irrigation has increased the yield of marketable potatoes the past season by 95 bushels an acre, and, as a 16-year average, the increase has been 84 bushels more potatoes. Increase hay yield from irrigation is about two tons an acre and is brought about for late cuttings during the drier part of the season. Beans have been a very profitable crop under irrigation. About six inches depth an acre is required for annual crops and ten to twelve inches is sufficient for perennial meadow crops on our heavy soils of the Valley floor. About 50 percent more water is required on the sandy bottom land.

Miscellaneous studies. (1) Soil correction trials on black sticky soil have been continued. Applications of lime and manure have increased the yield of rye-grass and Alsike clover. This is one of the most suitable crops for this land, on account of its heavy texture, and it is desirable to keep such land seeded down as much as possible.

(2) Tillage and soil moisture studies have been continued in connection with irrigation and drainage experiments. Lime and manure have given increased average moisture content during the recent dry summers on the soil experiment fields at the Home Station. These treatments have decreased the water requirement per unit dry matter, and the water requirement has been cut into by the use of rotation and manure.

(3) A study of the amounts and different kinds of replaceable bases in the alkali soils from the Vale experiment field, and certain heavy soils, particularly the red hill soils in Western Oregon, have been taken up. The amount of replaceable sodium relative to the amount of replaceable calcium is very important in connection with reclamation of alkali land.

The presence of too much sodium tends to maintain hard structure, while lime has the opposite effect. So-called "zeolitic" minerals are found in certain red hill soils, indicating a large proportion of replaceable bases.

(4) A new study is under way to determine the crop-producing power of limited amounts of essential nutrient elements. By nutrient solution experiments it is found that 28 to 30 parts per million of sulfate is necessary for best growth and certain of our soils solutions contain only half that amount. The amount of soluble calcium in certain Western Oregon soils is found to be very low. An experiment under way will determine the amount necessary for best growth. Nitrate, phosphate, and potash are also included in this study which should show the crop-producing power of limited amounts of plant food, and the amount necessary in the solution for best growth, particularly in the early growth period.

DEPARTMENT OF AGRICULTURAL CHEMISTRY

INVESTIGATIONS IN ANIMAL NUTRITION

Early in the biennium ending June 30, 1924, the Department of Agricultural Chemistry was entrusted with the development of fundamental research in the field of animal nutrition. Under the leadership of Dr. Harry G. Miller work in mineral metabolism was commenced promptly and is progressing satisfactorily. Continuance of earlier work of experimental feeding of small animals (rats) has been given prominence in the expectation of securing further light on the relation of inorganic elements to maintenance, growth, and reproduction. Thus far varying results have been secured in reproduction with rations compounded in such a way that mineral elements are carefully controlled. Extracting corn with water removes some constituent necessary for reproduction. The deficiency is not compensated for by added minerals, but is readily supplied by wheat embryo, alcoholic extract of wheat embryo, and green kale. Results of this preliminary work will soon appear in the Journal of Biological Chemistry.

Mineral metabolism studies with dairy cows were undertaken to ascertain the mineral balance existing when high-producing animals were fed the ordinary dairy rations of Oregon, and to determine the advisability of supplementing the ordinary ration with minerals. Calcium and phosphorus were in negative balance during the early lactation period. Addition of bone meal to the ration increased the retention of both elements to an extent sufficient to change the balance to positive. Equilibrium of other inorganic elements was maintained when the total experimental period is considered. Kale both increased milk yield during early and late lactation, and influenced favorably mineral storage in the animal body. A paper dealing with observations and work of the early lactation period appeared recently in the American Journal of Physiology. A paper dealing with the experimental results during late lactation and after heavy production is about to be offered for publication.

The chemical end of mineral metabolism studies is maintained entirely with the Adams Fund. The work with dairy cattle is conducted cooperatively with the department of Dairy Husbandry.

Insecticides and Fungicides

In the study of insecticides and fungicides, the physical properties of those materials are still being given most prominence.

The use of spreaders in spray materials is demanding a great deal of attention. The department research work in this field has been with certain fundamental problems that are involved when spreaders and sprays are intimately mixed. The relation of surface and interfacial tension of various spreader materials to the actual spreading property of these materials on the apple fruit and several different kinds of leaves was studied in considerable detail and reported in a recent number of the Journal of Agricultural Research. As an outgrowth of the theoretical study of spreader material, skim milk, clabbered milk, and dried skim milk were found to be especially suitable for use in the preparation of substitutes for several important sprays. Each facilitates the wetting of flowers of sulfur, which when mixed with hydrated lime, gives an excellent substitute for self-boiled lime and sulfur and other semi-strength sulfur sprays. The method of preparation involves less labor and time and is much cheaper than other sulfur sprays. Field trials indicate a very promising spray.

It has been found, too, that skim milk and other milk products may also be used as an emulsifier in the preparation of cold mineral oil emulsions. This type of emulsion is now being used as a substitute for lime-sulfur and for the more expensive potash soap oil emulsions. Field tests, conducted during the past spraying season, indicate that skim milk is the most effective of the spreaders, is the least expensive, and the most easily applied. Comparisons included the commercial casein spreaders. A report on the uses of skim milk and milk products in spray material was recently published in the Journal of Economic Entomology. A press article descriptive of the manner in which skim milk may be used as a preferable substitute for the commercial casein spreaders was also recently sent out.

Cooperative work with the Hood River Branch Experiment Station on methods for controlling anthracnose by means of bordeaux mixture shows promising results.

Especial attention has been given to methods of procedure in the home mixing of spray materials. Experiment Station Bulletin 201, The Preparation of Spray Materials, was prepared to give fruit growers recommendations that had been thoroughly tested. An article on the new methods of preparation of high-grade bordeaux mixture was also published in the Journal of Industrial and Engineering Chemistry.

The growing importance of copper carbonate as a fungicide for the control of smut and other small grains necessitates some laboratory study of the many brands that are on the market. In this the department is cooperating with the department of Plant Pathology.

Fertilizer Tests

A new nitrogen fertilizer, "Soda Nitrogen," was recently introduced into Oregon. It is largely sodium nitrite ($NaNO_2$) for which reason its use is somewhat questionable. A study was therefore undertaken to secure reliable information regarding its behavior in the soil. It is especially desirable to note to what extent this material is oxidized in the

soil and what losses there might be through volatilization of the decomposition products when the material is used on acid soils. From tests conducted with several types of soil in small pots, it was evident that very little oxidation of nitrite nitrogen occurred. It was also evident that large losses of nitrogen occurred in acid soil through the volatilization of decomposition products. Field tests substantiated the conclusions reached from work with soil in the pots. Steps were taken then to discourage the further importation of this material for fertilizing purposes.

Soil Investigations

Chemical analyses of soils that have been systematically surveyed and mapped by the Bureau of Soils of the United States Department of Agriculture and the Soils department of the Experiment Station are kept abreast of the field work as nearly as can be. During the biennium analyses were made of the mapped types of Polk and Benton counties. Results were summarized and are on file in this office and in the office of the department of Soils. Chemical analyses for the soils of ten counties are now available. They are as follows: Columbia, Yamhill, Washington, Multnomah, Clackamas, Hood River, Polk, Lincoln, Jackson, and Josephine. Preparation is being made for the same kind of work in Linn and Lane counties.

The acid reaction of soils in the Willamette Valley determines, in a large measure, the kind of crops that can best be grown. This fact is one to be reckoned with particularly in all attempts to extend the growth of this or that leguminous crop. Those which will accommodate themselves to the greatest intensity of soil acidity are especially to be recommended for growth here. Common vetch is an outstanding example. The department's project on acid soils was continued into this biennium by a study of the intensity of reaction prevailing in the most prominent series and types of Eastern Benton county. A report of the work, somewhat technical in nature, appeared in a recent number of Soil Science.

Additional cooperative work has been undertaken with the Hood River Branch Experiment Station. From it are expected sufficient data to establish the sufficiency or insufficiency of legume cover-crops for meeting the nitrogen requirements of producing orchards.

Yellow Berry in Turkey Red Wheat

The work originally outlined for the study of the cause and remedy for Yellow Berry in Turkey Red wheat is practically completed. It will be suitably summarized and reported in the near future.

Enforcement of Control Laws

The department is entrusted with the enforcement of the State Fertilizer, Lime, and Insecticide Laws. About 150 samples of fertilizers have been systematically taken and analyzed during the biennium, and 100 samples of insecticides since the law went into effect, March, 1923. Consumers of these products are very effectively guarded against fraudulent and low-grade materials. Sale has been stopped on six fraudulent spray materials.

DEPARTMENT OF BACTERIOLOGY

Investigations in Soil Bacteriology

The effect of lime on the biological activities in acid soils is the major problem of the department. The Biennial Report for 1920-1922 contains a description of greenhouse studies on three prominent local types of soil. Under greenhouse conditions these soils gave marked response to the application of lime as indicated by an increase in the yield of clover and also in the nitrifying, azofying, and ammonifying powers of the soil.

Field studies. The fact that these soils responded to the application of lime under greenhouse conditions cannot counteract all the adverse opinions that have been drawn from field observations where lime has been used. This led to the study of field conditions during the growing season. In this study observations were made on the experimental field where lime has been applied under different systems of cropping. The soil is "Willamette Silty Clay Loam" and most of the plots studied were cropped to barley.

Observations and data on the rotation plots during 1922 indicate:

1. That during the early season the barley on the limed plots was greener and more luxuriant than the unlimed plots.

2. That the texture of the soil was much better on the limed plots.

3. Tests for nitrates revealed only a trace until the crop had been harvested.

4. Climatic conditions are very unfavorable for the following reasons: (a) The nitrates are all leached out during the winter. (b) The soil remains cold late in the spring, thus retarding the formation of nitrates. (c) The rains cease about the first of June. At this time the soil is approaching optimum temperature for nitrate formation and soon afterwards the moisture content of the soil is too low for maximum nitrate production.

5. Increases in the nitrifying and azofying powers of the soils were analogous to those obtained in the greenhouse.

Observations on the fertilizer plots were made during the season of 1923-24. During 1923 these plots were cropped to oats and in 1924 to corn.

1. In none of these plots was there more than a trace of nitrates during the growing period of the oats.

2. Corn does not exhaust the nitrates. The greatest accumulation of nitrates was found in the plots receiving 3,000 pounds of hydrated lime, and twelve tons of manure, respectively. The least amount of nitrate was found in the checks and in the sulfured plots.

3. Nitrification tests in the laboratory correlate very closely with the field observations on the accumulation of nitrates. Liming and manuring accelerate the nitrifying power of the soil.

Observations on fallow plots were made during the seasons of 1923 and 1924 on fallow plots lying adjacent to each other that have been cropped continuously to grain since 1914 with no fertilizer added. These

plots have been treated at the rate of 0, 2, 4, and 6 tons of lime respectively per acre. The observations indicate:

1. Nitrates do accumulate in these fallow plots. A heavy mulch keeps the soil in fine tilth. The most nitrate was found where the largest application of lime was used.

2. The nitrifying power of these soils was stimulated by the application of lime. The greatest nitrifying power was found in the plot receiving six tons of lime; four tons of lime had a very marked effect, whereas two tons of lime was only slightly superior to no lime. These results are in correlation with the amount of nitrate found in the field samples. It must be remembered that these soils had been impoverished by continuous cropping to grain. It is quite possible that in the presence of an application of manure that the two-ton application of lime would have shown a marked increase over the unlimed plot.

Conclusion. We do not hesitate to say that Willamette silty clay loam does respond to the application of lime in the field as well as in the greenhouse. Larger quantities of nitrates were found in the limed plots and laboratory tests show that the nitrifying and azofying powers of these soils were stimulated. Failure to observe crop response is due either to the fact that crops which did require nitrate have been observed, or that other limiting factors prevented crop response.

Studies on Sulfur Oxidation in Soil

The Biennial Report for 1920-1922 contains a brief summary of investigations concerning the oxidation of sulfur in Oregon soils. These investigations have been continued and a study has also been made of the buffer qualities of these soils studied. The results have been reported in an article entitled "Studies on Sulfur Oxidation in Oregon Soils" (Soil Science Vol. 16, No. 6, pp. 479-490, 1923). It was observed that:

1. All soils included in the investigation were capable of oxidizing sodium sulfide and flour sulfur. While there was considerable variation between soils in sulfur-oxidizing efficiency all appeared to be able to oxidize enough sulfur to supply the needs of starving plants within a comparatively short time.

2. A general relationship exists between sulfofying power and sulfate content, curves representing these running more or less parallel.

3. No relation is apparent between total sulfur content and sulfofying power.

4. No relation exists between total sulfur content and sulfate content.

5. Application of sulfur to a soil tends to increase the sulfur-oxidizing efficiency of that soil.

6. Inoculated sulfur stimulates sulfofication, but for the soils studied its need was not indicated.

7. Temperature and aeration are important factors affecting sulfofication, an increase in either tending to increase the rate of sulfur oxidation.

8. The buffer qualities of the soils studied were indicated by their change in hydrogen-ion concentration. The heavy soils show a remarkable ability to neutralize the acidity formed through the oxidation of sulfur. The soils studied having high buffer value were heavy soils in which sulfur oxidation was slow compared to the light, sandy soils of low buffer value.

9. No apparent relationship exists between the hydrogen-ion concentration and the sulfur-oxidizing power of a soil.

Relation of Sulfur to Nitrate Formation in the Soil

To check on the relation of sulfur oxidation to nitrate production, some tests and observations were made on a sample of Carlton clay loam. A large sample was procured from the field and divided into seven portions and treated as follows: No. 1, check; No. 2, 100 pounds of sulfur per acre; No. 3, 500 pounds of sulfur; No. 4, 200 pounds gypsum; No. 5, 100 pounds sulfur and 2,000 pounds of lime; No. 6, 500 pounds sulfur and 2,000 pounds of lime; and No. 7, 2,000 pounds of lime. These samples were divided into two parts and placed in four-gallon jars in the greenhouse. One jar was kept fallow for sampling purposes while the other sample was planted to clover. Though this work is in progress certain things seem apparent:

1. That the application of sulfur alone depresses the nitrate-producing power, whereas 100 lbs. of sulfur applied with one ton of lime stimulates the nitrate-producing power of Carlton clay loam.

2. Lime and sulfur together gave the largest yield of clover under greenhouse conditions. The second largest yield of clover came from 100 pounds of sulfur alone per acre.

3. Oxidation of large quantities of sulfur materially lowers the yield of clover and also the nitrate-producing power, whereas the acidity is greatly increased.

Cross-Inoculation of Legumes

Our present lists of legumes prepared by investigations to show which crops will cross-inoculate are inaccurate. It has generally been accepted that horse-beans *(Vicia faba)* and Purple vetch *(Vicia atropurpurea)* would cross-inoculate with the vetch and pea genera. Difficulties encountered in getting a stand of these crops in the field led us to try some cross-inoculation studies so that we would be able to supply these organisms to the farmers. By employing sterile sand in greenhouse pots to grow seedlings in we were unable to get cross-inoculations on to the horse-bean and the Purple vetch from cultures isolated from Canadian field pea, sweet pea, Hairy vetch, and Common vetch. Neither would the bacteria isolated from the roots of these plants produce nodules on the horse-bean or the Purple vetch.

Miscellaneous Studies and Service

Cultures for legume inoculation. During each fiscal year legume cultures sufficient to inoculate about 7,000 acres of land were put out by this department. The great majority were distributed in the State of

Oregon, a few in the neighboring states, and one or two samples of these sent to foreign countries.

Hemorrhagic septicemia vaccine. There were 3,850 doses of this vaccine sent out during the last year. This is less than usual and may indicate that the disease is being controlled better, or it is possible that the outbreak of the foot-and-mouth disease in California disturbed the industry and detracted the attention from this trouble. It has been customary in years past for the large sheep-owner to vaccinate all the animals before shipping them into California, or immediately after receiving a shipment from California. The outbreak of the disease prevented this interchange to a considerable extent this year and may have affected distribution of the vaccine.

Water and milk analyses. There were 450 separate analyses of water made by the department the last year. Of these, 340 were made off the campus and 110 on the campus. Of the 340 samples received from outside sources, practically two-thirds of them necessitated a follow-up letter and assistance rendered intending to remove the difficulty. In many cases this necessitated three or four letters beside a study of the situation in an attempt to improve conditions. About 550 bacterial tests of milk and cream were made during the last year and a similar number the preceding year.

Miscellaneous clinical diagnoses. During the last fiscal year 1,234 tests were made, only 54 of which were made on the campus. This includes every kind of a test made by the ordinary clinical laboratory, as an aid to the physician in diagnosing. Literally hundreds of cultures were grown and diagnoses made last year during the epidemic of diphtheria. Blood tests were run, sputum analyses made, typhoid determinations run, vaccines made, and even virulence tests on experimental animals conducted when called for. This work is paid for in part and part is gratis.

DEPARTMENT OF FARM MANAGEMENT

Funds

No budget or permanent funds for Farm Management work were available for this biennium. The former budget of the department for Station work ($1500 per year) the department had voluntarily relinquished as insufficient to carry through any permanent major project to completion.

During this biennium however, by securing the cooperation of the United States Department of Agriculture and the Oregon Agricultural College Extension Service, and using the time of the College instructional staff of the department, it was possible to carry forward the wheat cost project at a total expense to the Experiment Station itself of only $600 for the biennium, this sum being used for travel expense in the field work.

Projects

1. **Wheat cost project.** The second and third years of the field work on this three-year study of the Eastern Oregon wheat farm was com-

pleted during the summers of 1922 and 1923, and the data started on the long grind of computation.

During this three-year study the cost of producing over 3,800,000 bushels of wheat grown on over 160,000 acres of actual wheat land was obtained.

The records were taken yearly from 150 typical wheat farms in Sherman county for three years in succession. The capital investment in these farms was over $10,000,000. Every item of investment, cost, and returns, of farm organization and management and the vital factors therein, was obtained in this study.

The United States Department of Agriculture states that this is one of the most complete and thorough studies of wheat cost and wheat farming ever made anywhere.

Project leaders were R. S. Washburn, United States Department of Agriculture, and H. D. Scudder, Oregon Experiment Station.

2. **Prune cost project.** Field work on this project was begun in December 1923. The first year's work was completed, both field work and major computations by June 30, 1924, and mimeograph reports issued to growers.

This project was started in the fall of 1923 after the wheat project field work was completed. Like the wheat project, it was possible to undertake it only by using the College instructional staff and by cooperating with the Extension Service. The Experiment Station furnished one-half the travel expense in the field and some clerical assistance, totaling for the first year's work about $400.

The study covers 115 prune orchards throughout Western Oregon, obtaining every item of cost and returns, efficiency factors, etc., in the production of 5,000,000 pounds of dried prunes on about 2300 acres of bearing prune orchards annually, for a period of three successive years.

Factors in the prune farm organization and management are fully covered. The total capital investment in the farms studied aggregated over $3,000,000.

This survey is thorough and complete and the first of its kind (prune enterprise) undertaken anywhere. The department of Horticulture cooperates in this study.

Minor Projects

Shelter shed study. Some additional records were obtained dealing with the cost and efficiency of the shelter shed as housing for livestock and for storage of manure. Sufficient data are available to make a satisfactory publication. This work was done on college time.

Farm reorganization work. Six new farm reorganization plans were worked out during the period and turned over to the farmers concerned. It would be very helpful if this work could be followed up and through to completion, but time for this has never been available. This work was done on college time, Clair Wilkes assisting.

Farm building plans. Several additional building plans were completed and blue printed after extensive study of their types. A book of blue prints covering every important farm building in very complete

detail is now available and the plans are already widely used. A publication covering this work would be valuable. This work was done on college time, Clair Wilkes assisting.

Land clearing study. The results of some years of study under this head were published in December 1922 as Oregon Station Bulletin 195, Stump Land Reclamation in Oregon. The issue of 8,000 was exhausted in two months, except for a small number reserved. No further work on this project was contemplated at this time, because of economic conditions unfavorable to interest in or development of land clearing reclamation.

DEPARTMENT OF HORTICULTURE

The relation of general pruning practices and the resulting responses to the internal food changes in the tree as a whole. This work was begun in 1918. Results of this study have been chiefly of a general nature. It has emphasized the necessity of studying the pruning practices needed for each variety of tree, and the dangers underlying summer pruning. The specific data include cover-crop and growth records; starch transformation; total nitrogen and carbohydrates of the leaves and root studies.

Relation of leaf area of the individual spur to its chemical composition—and the formation of fruit buds. This work differed from the problem reported upon in Station Bulletin 176, The Relation of Carbohydrates and Nitrogen to the Behavior of Apple Spurs, only in the type of spur used. The results agree with previous findings that fruit-bud formation does not take place if the spur has not an adequate leaf area. In fact, the evidence from the last type of spur studied is clearer than that previously published.

The relative influence of the leaves and developing fruit on the chemical composition of the spur. Some interesting biometric data were obtained but the chemical results (which were the chief aim of the work) did not prove very satisfactory. While the results in themselves were generally disappointing, it was a very careful piece of work, and helps define our future task in that line.

Effects of ringing and defoliation on the chemical and external activities of apple branches. The external responses to various combinations of ringing and defoliation are very interesting; in general, they are as recorded two years ago from a preliminary experiment carried out by Mr. Murneek. The chemical data (of which only a small part is now available) seem to go far toward explaining some of the observed responses to the different treatments.

The physiology of summer shoots. The effects of ringing and defoliation on growth and chemical composition. This work was completed in the summer of 1923 and is described in the abstract of Station Bulletin 200, A Study of Growth in Summer Shoots of the Apple with Special Consideration of the Role of Carbohydrates and Nitrogen.

Study of the distribution and function of phloridzin in apple and pear shoots. This work was begun over two years ago. It was in-

itiated through the questioning of conclusions of Mitra that maltose is very common in apple tissue. Mitra had reported the presence of large quantities of maltose in apple branches and spurs. He had also developed an elaborate physiological theory to explain its presence and function. The results of this work go to show that maltose is not present in such tissues, the substance taken for maltose being phloridzin.

Experimental work other than Adams Project. Study of the growth of roots of fruit trees in winter. This problem was attacked very profitably by Mr. G. H. Harris during the winters of 1922-23 and 1923-24. He studied the relation of temperature and water-table to growth of roots in winter and found that in general there is no winter rest period in this region; that root growth is practically continuous from autumn to spring, providing the temperature of the soil, at any point under consideration, is slightly above zero Centigrade, and also providing that the water-table is below the roots at that point. Submergence is usually much more harmful than low temperature, for the reason that the root-tips which are growing before submergence do not resume growth after the recession of the water, but after a period of low temperature the root-tips begin growth at once.

Study of histological methods with reference to the filbert. Mr. Wharton attempted here to solve some of the technical difficulties encountered by Mr. Rimoldi in the latter's study of the pollination and fertilization of the filbert. It is believed that Mr. Wharton was largely successful so that the department is now in a position to make with ease some very exact observations of the details of pollination and of fertilization in the filbert.

Pomology Investigations

Variety tests in Eastern Oregon. Over 100 varieties of fruit trees, small fruits, shade trees, shrubs, and vines have been planted at each of the Branch Experiment Stations located at Moro and at Burns in Eastern Oregon. The purpose of these plantings is to test the adaptation of different varieties to the climatic factors of cold winters, frosty springs, summer drouth, and drying winds. It is hoped that within a few years, a list of varieties can be recommended for planting in Eastern Oregon which will be relatively certain of successful growth and fruiting.

Pollination Results

Filberts. The pollination tests on the filberts have been practically completed. As a result of these tests, it has been found that all varieties are commercially self-sterile and a few inter-sterile. The Barcelona can be cross-pollinated by the White Aveline, the Daviana, the Nottingham, and the Du Chilly. The pollenizers for these secondary varieties, together with other information on pollination of filberts, is contained in Station Bulletin 208, Filberts, just off the press.

Sweet cherries. Many sweet cherry seedlings have been tested in the last two years and all are self-sterile. It is hoped sometime to find a sweet cherry that will be self-fertile. In working on the commercial varieties, the Napoleon, Bing, and Lambert, it was found inadvisable to recommend pollenizers by varietal names alone. The nomencla-

ture of the sweet cherry is so badly confused that we cannot be certain what cherry is obtained under any one name. There are several different cherries being sold under the name of nearly every sweet cherry variety. Pollenizers for the commercial varieties should be chosen from trees proved efficient by experimental results, or by performance in the field. In connection with this work, certain trees of the Napoleon, Bing, and Lambert, together with trees used for pollination purposes, were certified as to their performances in the pollination tests. Scion wood taken from these trees and used in propagation of trees in the nursery should give a combination of young trees for planting in orchards that will not fail to produce crops.

Sour cherries. The sour cherry varieties, as shown by investigations during the past two years, may be either self-sterile, partly self-sterile, or self-fertile. With the exception of the Suda and English Morello, all sour cherries are either self-sterile or partly so and as a result need interplanting with other varieties to bear commercial crops. The varieties most commonly planted, the Montmorency and the Early Richmond, cross-pollinate sufficiently well as to insure crops of both varieties. As with the sweet cherries the nomenclature is badly confused and it would be the safest plan to interplant the sour cherries in order to insure a paying crop.

Pears. Pollination work on the Anjou in 1923 was indefinite, as all varieties of pollen used, excepting the Kieffer, gave a set of fruit. These results are contradictory to the 1922 results and the usual field results. A study of the results shows a very erratic set of fruit, leading to the belief that other factors than pollination are responsible for the usual light set of fruit on the Anjou variety. Tests on the Bartlett show that under Willamette Valley conditions this variety is practically self-sterile.

Miscellaneous pollination. More than 150 apple varieties were tested as to self-sterility and it was found that nearly all are self-sterile, or practically so, hence they would be benefited by interplanting but a few showed indications of being fully self-fertile. The plums and prunes could also be divided into the three classes of self-sterile, partly self-sterile, and self-fertile.

One season's tests with chestnuts indicate that they are self-sterile, but quite readily cross-pollinate. The self-sterility of some varieties on the Station grounds can be explained by the fact that they fail to produce pollen, though the male catkins are borne in abundance. Where pollen of a foreign variety was introduced and applied to the pistils, chestnuts were borne in large quantities. A study was made of the flowering habits of the chestnut in connection with the pollination work and during the past two seasons blooming records of over 300 varieties of fruit have been taken.

The Mammoth blackberry proved self-sterile in two year's tests. It readily cross-pollinates with pollen from other blackberry varieties.

Fruit Breeding and Variety Trials

Strawberries. Seven hundred seedlings have been fruited, the best of which have been selected for future test and for continued breeding. The main aim is to produce a berry of the canning quality of the

Ettersburg 121 that will bear consistently. In this breeding work, the Ettersburg 121 has been used as the female parent and has been found very prepotent in transmitting the vegetative characteristic of this variety.

Apples. The Red Rome and Improved Rambo varieties continue to be the most promising of the new varieties. Among the seedlings raised on the Station grounds, little of value has been found, but in the block of seedlings sent in by people of the state are some of apparent value. These began to fruit for the first time last year.

The Golden Delicious has been found unsatisfactory under Western Oregon conditions. In this section, it develops a dry skin which does not permit of long keeping.

Cherries. A few of the cherry seedlings are showing promise as pollenizers for the Bing, Lambert, and Napoleon. These are being propagated for field tests as to cropping ability. They have also been canned where they appeared to have canning qualities.

Plums and prunes. One prune seedling has shown excellent quality. In 1924 it is bearing a commercial crop for the first time. As it is self-sterile it must be interplanted with other varieties, for which purpose the Italian has proved of value.

Miscellaneous Experimental Work

Attempts to propagate the filbert by cuttings met with no success. Descriptions of filbert varieties have been recorded and a few briefly published in Station Bulletin 208, Filberts.

Data as to resistance to winter killing, yields, and general behavior of the miscellaneous fruits is being kept on file.

Humidity in relation to the handling of filberts. This project has been carried on during the past year and is reported in Station Bulletin 202, The Relation of Humidity to the Texture, Weight, and Volume of Filberts. The experimental work done on this project seems to warrant the following conclusions: (1) Humidity has a definite bearing upon the water content and weight of filberts. (2) The water content of these nuts increases or decreases with the relative humidity of the air in which they are kept. (3) At high humidities, water of considerable amount is contained both by the shells and the kernels of the filberts.

The rate at which filberts gain or lose moisture is dependent upon (1) relative humidity; (2) water content of the nut; (3) temperature; and (4) aeration. All conditions being equal, the rate of gain or loss is greater in the case of the kernels than in that of the shells. The texture of filberts seems to be affected considerably by changes of the water content, being more or less soft when the water content is high and becoming hard and brittle as it diminishes. To be in good condition for eating, filberts should contain from 12 to 15 percent water. To maintain or acquire this amount of moisture, the nuts should be subjected to a relative humidity of at least 80 percent. When the moisture content of filberts is high, their cracking quality also is much better than when they are comparatively dry. Nuts that have been dried and then allowed to regain their water content, appear like fresh nuts both in eating and cracking qualities.

The volume of filberts varies in direct proportion to their water content. Every gain or loss in moisture is apparently accompanied by a gain or loss in volume. Volume changes occasioned by moisture changes are sufficient to have a bearing upon the matter of grades and standards for marketing.

Filberts are susceptible to the attack of decay organisms, chief among which are certain forms of mold. They frequently mold in the field or become contaminated so that they become moldy after harvesting, and, consequently, they should be gathered from the ground as soon as possible. To be free from danger of mold, filberts should be dried down so that the water content is below 12 percent. This may be done very satisfactorily under living-room conditions. Excessive drying of filberts is not necessary. It does not seem advisable to keep filberts in a fresh condition during the entire period of storage. It is best, seemingly, to allow them to dry down to a safe water content and then freshen them before eating.

The loss of moisture in filberts may be retarded more or less by the use of certain wrapping papers. One of the best is heavily coated paraffin paper. Common wrapping papers did not prove effective in the preventing of loss of moisture. Air-tight containers, seemingly, are undesirable in handling of filberts, due to the fact that nuts placed in such containers for any length of time become stale and lose their characteristic flavor.

Harvesting and storage of pears and apples. Studies relating to the harvesting and storage of pears have been in progress at the Oregon Experiment Station since 1917. During the last biennium, the scope of the work has been extended so as to include more generally the winter varieties of pears, and certain studies dealing with the handling of apples. This work is reported in Station Bulletin 206, Studies Relating to the Harvesting and Storage of Apples and Pears.

Conclusions arrived at are that the loss of weight after harvesting may be a considerable factor in the handling of pears. Excessive loss of weight not only results in decreased tonnage, but causes wilting, which seriously impairs the appearance of the fruit. Wilted pears are usually dull and unattractive in appearance, and are not aromatic. The loss of 3 to 4 percent is sufficient to cause noticeable wilting. Insufficient humidity in the air appears to be the chief cause of wilting. Storing fruit in a humidity of 80 to 85 percent practically prevents loss of weight. Apparently each loss of weight is accompanied by a corresponding loss of volume. Time of picking also has a bearing upon loss of weight. Bartlett pears picked on August 14 lost 9.7 percent of their weight during 264 hours of storage, while those picked on September 14 lost only 5.8 percent of their weight during this time (under Willamette Valley conditions).

Pears from heavily loaded trees are usually more advanced in maturity than those of lightly loaded trees in the same orchard. A pressure testing machine described in a previous bulletin indicated that the time of picking pears on heavily loaded trees may be from 8 to 12 days earlier than that of pears on lightly loaded trees.

Such general indicators of maturity as easy removal of specimens from spurs, color of seeds, and size of fruit, were found to be unreliable.

The most reliable test of maturity is that given by the pressure tester. The number of pounds registered when the fruit is ready to be picked will differ considerably upon the different varieties of pears. Anjou seems to have a rather long picking season and should be taken from the tree when the pressure tester registers between 24 and 19 pounds. Comice, on the other hand, has a fairly short picking season, running from 8 to 10 days on the average. It should be picked when the pressure tester registers between 20 and 18 pounds. Winter Nelis has a rather late and long picking season and may be picked when the pressure tester registers between 33 and 29 pounds, *on clear skinned specimens.* The results obtained with Bartlett corroborate closely those of previous investigations. Picking should take place when the pressure tester registers between 35 and 25 pounds.

Core rot in pears seems to be associated with over maturity. No evidence of this trouble was noted in Bartlett and Comice except in the lots that were picked comparatively late in the season.

In using the pressure tester on apples it was found that the apple does not show a sufficient decrease in resistance prior to the time of picking to make this test a reliable guide for picking. As an indicator as to the condition of apples after harvesting, however, the pressure tester gives considerable assistance. Indications are that the Grimes Golden variety is commonly picked prematurely in the Willamette Valley. From September 17 to October 20 an increase in size of 31.4 percent was noted in this variety. Grimes Golden is not troubled with internal breakdown when it hangs late upon the tree. Jonathan, on the other hand, must be picked at the right time or internal breakdown will develop. There is a tendency to leave this variety on the tree too long in order to get high color. Fruit picked September 17 developed only 5 percent breakdown during the storage period, while that picked on October 20 was affected to the extent of 79 percent.

Storing and harvesting of cherries. This is a report on the work undertaken this year for the first time. For the work thus far done, we seem warranted in drawing the following conclusions: Both sweet and sour cherries are commonly harvested too green in Oregon; after trying several methods of testing maturity, it was found that a test based upon the percent of soluble solids in the juice is a good index of ripeness; cherries show rather remarkable increases in soluble solids during the harvesting periods. For example, Royal Ann increased from 12.0 to 22.4 percent; Lambert from 11.3 to 22.2 percent; Montmorency from 12.0 to 18.8 percent. There is also some decrease in the percentage of acid in cherries during harvesting. Royal Ann showed a decrease from .636 to .348 percent malic acid during the picking season. Lambert and Montmorency showed similar decreases.

Cherries increased decidedly in size during the entire ripening period. Lambert, for instance, increased from 5.96 grams on June 24 to 8.02 grams on July 22, or slightly over one-third in weight.

It seems evident then, that picking is a very important factor in the handling of cherries, both for fresh fruit and canning purposes. Early-picked Royal Anns when canned are small in size, dead in color, and flat in taste. They show more or less shriveling when canned in sirup. Those picked later in the season have a livelier appearance, are larger in

size, are more aromatic, and have a decidedly more pronounced cherry flavor. They show no shriveling in the sirup and are fully as firm as those picked earlier. Their juice gives a higher sugar test in the cans.

It was noted that cherries picked early in the season wilted much more than those picked at full maturity. Humidity is a very important factor in handling cherries. When picked and handled in low humidity cherries wilt badly and lose considerably both in weight and volume. There is no indication that high humidities are favorable for the introduction of decay organisms. In fact plump, turgid specimens, as the result of high humidity, seem to withstand better the attacks of mold and similar decay organisms.

Carbohydrate injection of Anjou pears. This test was undertaken as a corollary to the nitrate-injection work done by Harvey and Murneek in 1919. Carbohydrates in the form of sucrose and glucose were injected into Anjou pear trees at blossom time. Shortly after injection a general reddening of the foliage was noted. This persisted for a short time and disappeared. No material effect on the set of fruit was noted. Observations will be continued next year to see if there are any residual effects from this kind of treatment.

VEGETABLE GARDENING

Experimental Work

The experimental work of this section may be divided into three parts; namely, seed strain tests, cooperative fertilizer trials, and work with greenhouse tomatoes.

Seed strains. An especially fine strain of Refugee stringless bean was tested in 1923 for the first time. This proved to be particularly valuable for canning purposes and during the season of 1924 has been tested out on a large scale by one of the best canneries in the state, where it has given very good satisfaction.

Tests with beets show that there is a wide difference in the interior color of the roots between various strains of the same variety and also different varieties. Of the best strains tested, some 81 percent of the roots are of a desirable canning color, while 19 percent are zoned, making them undesirable for canning. There is need for careful selection to overcome the zoning tendency.

Field trials with cabbage to determine heaviest producing strains and varieties have been carried on over one year only. More trials will be needed before recommendations can be given.

Broccoli seed strain trials have been continued from previous years, 42 strains now being used. No results can be definitely stated until after this season's trials can be completed. Growers have suffered tremendously in years past due to poor seed strains; one instance being reported of only 100 crates being harvested from 100 acres because of the fact that the strain of seed used did not produce heads.

Cooperative fertilizer work with onions and onion sets. Different combinations of commercial fertilizers including potash, superphosphate and in some cases, nitrogen, were applied to fields of onion sets near Sa-

lem, Oregon. It was found in a general way that the greatest yields were obtained from the use of a complete fertilizer containing the three elements above mentioned, but the results indicated that the yields of individual plots were influenced by agencies other than the fertilizers applied. The chief limiting factor evidently was a natural variation of the soil and possibly also a variation in the drainage of the area.

In the fertilizer trials on large onions, severe maggot attacks on the trial plots made an accurate comparison of yields impossible.

All of this work points to the fact that definite conclusions cannot be reached from the application of fertilizers, unless other conditions of soil, drainage, insect pests and plant diseases, can be absolutely controlled.

Pollination of greenhouse tomatoes. This work has been under way in the greenhouses of the Vegetable Gardening section for several years. It was undertaken to show, if possible, how growers might improve their yields of tomatoes grown under glass. The average yield as reported from growers is from 5 to 8 pounds per plant. The average yield on plants in the experimental greenhouse was 11 pounds 5 ounces per plant. This result was obtained on four blocks containing 204 plants. These plants showed a striking uniformity in growth and yield. In these plants, 27 percent of the total amount of fruit was produced during the first period while prices were highest, 68 percent during the second period, and 5 percent during the final period.

HORTICULTURAL PRODUCTS SECTION

Recirculation Driers

During the last biennium, experimental work has been continued upon factors influencing the drying of prunes, emphasis being placed upon the control of temperature, humidity, and circulation of air. This work has resulted in the designing of a new type of drier provided with a multi-vane fan to cause recirculation of air. This system of drying has been given the name of "recirculation drying" for that reason. A full description of the work will be found in Station Circular 40, Recirculation Driers, and Station Bulletin 205, Drying Prunes in Oregon.

Walnut Investigations

During the past year, experiments were carried on in the drying of walnuts. One season's work seems to indicate that walnuts can be dried in from 24 to 36 hours, depending upon their size, at a temperature of from 100 to 105 degrees, with a circulation of air running from 250 to 500 lineal feet per minute. Under the old system of drying in tunnels, having a natural draft, with temperatures between 90 and 100 degrees F., the drying time takes from 50 to 75 hours. The saving in time and labor under the new system is very apparent. The method used for drying nuts was a recirculation system similar to that used in drying prunes, with the exception that bins were used, instead of tunnels, which were 10 x 10 feet square and 3 feet deep. Nuts were filled into the bin at varying depths running from 2 to 3 feet. The bottoms of the bins

were covered with wire screening to allow passage of warm air through the nuts. This air passage was brought about by a No. 8 Sturtevant fan revolving 400 revolutions per minute, and delivering approximately 19,000 cu. ft. per minute.

Experimental Work With Gooseberries

Due to the fact that many commercial cannerymen have been complaining about hydrogen gas forming in packs of gooseberries, work was begun by the Plant Pathology and Horticultural Products sections cooperating, last year, to discover the cause of the trouble. It was found that when gooseberries were given all the sprays recommended the sulfur which had been applied to the berries to control mildew, either in the form of lime-sulfur or dust, caused the swelling in the canned goods due to hydrogen gas. This swelling was noted earliest when the fruit was packed in plain tins. The hydrogen gas developed, however, in all fruit so sprayed, whether it was canned in plain single enamel or reenameled cans.

Sprays applied before the berry was formed caused no spoilage. This has led to a change in the recommendations for spraying gooseberries. Further tests will be carried out during the coming year.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

Experimental Results

Verticillium wilt disease of potatoes. This project, of great importance to the potato industry of Oregon, was practically completed and the results are being prepared for publication. The rotation test begun in 1919 was finished. It proved conclusively that the wilt fungus can be eliminated from diseased soil by a rotation of three years between potato crops, but that it is not possible to obtain satisfactory reduction of the disease in a shorter length of time. It may be recalled here that to eliminate Rhizoctonia from the soil a four-year rotation is required.

Experiments to find out how far the wilt fungus will spread in the soil showed that infection of healthy plants may be secured by placing the fungus in the soil at a distance of forty-five inches from the seed piece. This helps to show how readily the wilt disease can spread from plant to plant in the row and proves the wisdom of the three-plant method of roguing where the potato-grower wishes to raise a seed crop as free as possible from internal wilt infection. According to this method, when a wilt-diseased plant is discovered it is immediately pulled up and with it the plant on each side is removed, since these have probably taken the infection already, though not yet showing the symptoms, and if allowed to remain would only serve to spread the wilt further. In a field test of this method wilt infection in one plot was reduced from a little over 20 percent to a little less than 4 percent in one season's time.

Virus diseases of potatoes. Late in the biennium this project was started to meet the need for information as to the types of virus diseases present in Oregon, their mode of spread and the best means of controlling them. This class of troubles appears to be increasing rapidly and

is not only causing large yield losses annually throughout the state, but is menacing the seed-potato industry, because of the insidious nature, difficulty of detection in many cases in the field, and practical impossibility of detection in the seed tuber, which is the primary means of dissemination. The result of the first work in this investigation has been to show that the disease called "rugose mosaic," is the most important of the virus diseases in the state at the present time. It causes pronounced reduction in yields and spreads very rapidly. Among other virus diseases which have been recognized are mild mosaic, witches broom, leaf roll, spindle tuber, leaf-rolling mosaic and giant hill.

The preliminary studies and observations made thus far point to the urgent necessity of the widespread adoption of the seed plot plan for virus disease control as the only way at present known by which growers can even approach a reasonable degree of success in eliminating this class of troubles. This plan involves starting with the most nearly disease-free seed stocks obtainable, planting in an isolated plot at least 300 feet from any other potatoes, and from start to end of the season completely removing all plants showing disease as soon as the first symptoms are detected.

European canker of fruit trees. In addition to continued life-history studies which have confirmed previous observations, inoculation work and spraying experiments have been conducted. These show that leaf-scars are far more capable of infection immediately after leaf-fall than they are a week later, while pruning cuts, the other chief points of entry for the disease, are likewise more susceptible to infection at the time of pruning than seven days later. The investigator believes that the available facts point to a spray immediately after leaf-fall as likely to give most effective results, but since this would be so late in the fall that most Oregon orchardists could not drive a spray rig over the wet ground, it is believed best to continue the previous recommendation advising that bordeaux 4-4-50 be applied as late in the fall as is consistent with other orchard practices and the condition of the soil. Spraying is not found to check the progress of existing cankers, but only to prevent new infections. In order to control the disease successfully, existing cankers must also be surgically treated. Canker eradication has been conducted during the biennium in large pear acreages under the direction of Dr. Zeller. This work has demonstrated that the methods advocated by the Experiment Station where thoroughly applied, will produce effective results. Deep infections reaching to the cambium such as occur on Anjou pear trees must be completely cut out, but superficial bark infections such as are found in Bosc or Surprise pears can be successfully treated by shaving off the outer bark deeply enough to remove all traces of brown streaks in the bast fibers. All such surgical wounds are benefited by treatment with bordeaux paste. The project has been completed and a bulletin covering the work is being prepared.

Virus diseases of bramble fruits. On account of the serious deterioration and dying out of plants from unexplained causes occurring in the principal bramble-fruit growing sections of Oregon, and in response to urgent appeals for help from growers, particularly those in the Woodburn district, a project was established for the investigation of these troubles, which in the main, did not appear to be due to attacks of parasitic fungi, but which seemed rather to belong to that puzzling

class of serious plant disorders known as virus diseases. The first work was a careful survey of existing conditions followed by a trip to eastern bramble-fruit sections. Ohio, New York, and Ontario were visited in company with the eastern plant pathologists engaged in similar work.

These studies disclosed the fact that a number of distinct virus troubles are present and causing considerable losses in Oregon cane-fruit plantings, and showed that these troubles are continually being propagated to new plantings by the use of tips obtained from affected parent stock. Characteristic symptoms of the following troubles have been found in Oregon: mosaic, occurring in all types of brambles, but most prevalent in loganberries and blackcaps, and appearing in both a severe type and a mild type of which the latter is more common; leaf curl, found only in red raspberries in Oregon, and only in a few plants which have been destroyed; bramble streak, occurring in one of the best red-raspberry sections of Oregon where, however, it appears to be by no means as destructive as in the East; dwarf, affecting Phenomenal and loganberries, the former being apparently more susceptible, but the latter having shown upwards of 20 percent affected plants in some fields. Other troubles which may possibly be due to some virus have been noted, among them "webbing," "penciling," and "attenuation" of foliage.

Experimental work has been started with a view to determining the symptoms, development, and methods of transmission and destructiveness of these different troubles under Oregon conditions from season to season and also the possibility of practical control by use of disease-free or as nearly disease-free stock as obtainable, isolation, and careful roguing methods. A number of years will be required to work out these problems, but the permanent success of bramble fruit growing in Oregon depends, to a considerable extent, on the finding of practical ways of controlling the most destructive of these troubles.

Armillaria root-rot. Little progress has been made on this project during the biennium, partly on account of the freezing out of stock which was originally set out for this investigation, and partly because of diversion of time to the cane-fruit projects. The disease has been found on strawberries and definite observations of incipient infection of unwounded apple roots by the fungus have been made.

Fungous diseases of brambles. Along with the work on virus diseases, studies have been made on the diseases caused by parasitic fungi. One of the most destructive, where present, is the "blue-stem" disease of blackcaps, caused by a species of Verticillium which is suspected of being identical with the potato-wilt fungus. Reports indicate that the disease is especially apt to be severe where blackcaps follow a potato crop. The death of plants is usually worst the third year after planting and as high as 52 percent mortality from the disease has been observed in a single planting. For new plantings, sets should be taken from fields which do not show the disease while rotation with crops not subject to the fungus will probably clean up infected soil in two or three years. Further experiments are going forward.

Spur blight due to *Mycosphaerella rubina* has been found rather general in Western Oregon affecting mostly loganberries and red raspberries. It has not been found to affect production seriously except on raspberries in

the Ashland district. Spraying experiments are being conducted through the cooperation of the Southern Oregon Branch Experiment Station. Cane blight, due to *Leptosphaeria coniothyrium,* does not appear to be very prevalent or serious in Oregon, although spur infections on loganberry and blackberry have been found.

Raspberry rust, due to *Phragmidium imitans,* is widespread in Western Oregon red raspberry plantings, and to a minor extent on blackcaps. In seasons when abundant, the disease may cause serious infections near the base of the canes, but the fungus is often so abundant on red raspberry foliage, where its orange-colored dusty spores are produced in enormous quantity, that some reduction in vitality must result.

Anthracnose *(Plectodiscella veneta)* appears to cause but little damage in Oregon, although widely distributed. Most of the troubles in cane fruit plantings attributed by growers to this disease are believed to be due to the work of other fungi. The leaf-spot caused by *Septoria rubi* is commonly mistaken for anthracnose which it resembles. This trouble is rather abundant and serious in some plantings of loganberries and blackberries (especially Himalaya and Mammoth). Attack on canes as well as leaves is common. One of the most common fungi found on red raspberry canes is *Ascospora ruborum,* the common conidial stage of which has been known as *Coryneum ruborum.* Dr. Zeller discovered the perfect or ascogenous stage. The disease works in the outer bark causing brown discoloration in summer and gray spots in winter.

Miscellaneous orchard cankers and other troubles. Continued studies have been made of minor fungi which are present in Oregon orchards. The serious apple black-rot and canker fungus of the Eastern United States, *Sphaeropsis malorum,* is widespread throughout Western Oregon, but it causes practically no economic damage, due probably to the fact that the climate of our growing season is unfavorable for black-rot infections or development. Another common fungus is the bark-canker fungus *(Myxosporium corticola),* which does little damage under Oregon conditions.

Wound disinfection for heart-rot prevention in fruit trees. Field surveys have shown the great need for an efficient dressing for pruning or other wounds to prevent the invasion of decay into the bodies and limbs of fruit trees. The conditions resulting from infection at unprotected cuts made in removing limbs are far worse in peach and prune trees than in apple and pear. This may be due in part to the greater susceptibility of stone fruits and in part to the more regular and thorough spray program employed in apple and pear orchards. At any rate a survey of many orchards has revealed that between eighty and ninety percent of the trees in the average mature prune or peach orchard have heart-rot, examination showing decay present in from thirty to forty percent of the wounds made in removing limbs. In well-cared for apple orchards less than one percent of decayed wound was found, and in pears only a little over one percent, even though no special methods had been used to protect the wounds. On the other hand in unsprayed, abandoned apple orchards, heart-rot from pruning cuts appeared to run as high as eleven and one-half percent. Also, in some especially well-cared for prune orchards visited, only four and one-half percent of the trees showed visible heart-rot and only three percent of the limb cuts showed decay. It is evident that the systematic use of bordeaux and lime-sulfur

sprays are an aid in preventing wound infections, but the need for a special antiseptic wound dressing is still evident. In the tests of twelve different kinds of wound coverings started in the spring of 1921, one of the materials stands out as superior to the rest, after three years of observation. This is the bordeaux-linseed-oil paint made by mixing commercial bordeaux powder with linseed-oil until it has the consistency of heavy paint. This is best applied as soon as the wound surface has dried after limb removal. It has shown itself to be permanent over a period of at least three years, practically non-injurious to the exposed cambium, apparently air-porous and not hard enough to interfere with callus growth.

Potato seed treatment. Previous tests conducted under the project have shown the very great superiority of corrosive sublimate over cold formaldehyde solution for the surface disinfection of seed potatoes. As a result the corrosive-sublimate treatment has become standard in Oregon. Recent work at other experiment stations has shown that hot formaldehyde solution is much more efficient than the same solution unheated. Furthermore, certain organic mercury disinfectants have been put forward lately with a claim that they do not only disinfect the seed, but stimulate to better yields. A test has just been begun to compare hot formaldehyde and one of the best known chlor-phenol-mercury compounds with the older solutions referred to. Results are not yet available. An incidental but important disclosure resulting from the seed treatment tests is the fact that less Rhizoctonia developed in a crop grown from Rhizoctonia-covered seed disinfected with corrosive sublimate than in a crop grown from apparently clean seed not subjected to treatment. From this and other facts made evident by tests, it is clear that *all* seed potatoes, regardless of appearances, should be given standard treatment before planting.

Potato dusting. Spraying has long been demonstrated as an effective means of preventing the late blight disease of potatoes. The method has not, however, been widely adopted in Oregon. The expense of suitable equipment has held the growers back on account of the fact that acreages are mostly small in the regions where the trouble is prevalent while in other sections the disease is either unknown or occurs only occasionally and sporadically. Much interest has therefore been taken in the possible use of dusts, in lieu of sprays for blight control. The Experiment Station has directed dusting trials in two counties with such satisfactory results that it is believed that potato dusting for blight may well be used in Oregon wherever it is not practical to spray, especially for the grower with a small acreage. Inexpensive hand dusters may be used on acreages up to five acres and, all things considered, in such cases dusting costs no more than spraying, in spite of the greater cost of the fungicide used.

Alfalfa stem-rot. This disease has appeared destructively not only in the older alfalfa-growing sections of Southern Oregon, but also in the Willamette Valley where it is being tried out extensively as a pasture and hay crop. The disease is due to a fungus tentatively determined as *Sclerotinia trifoliorum*. Lack of funds and assistance has prevented an adequate attack on this problem, but a short survey was made in the spring of 1924 in the Northern Willamette Valley, through the cooper-

ation of the Extension Service. In some fields as high as 50 percent of the plants were found severely affected, many being killed outright. The disease appeared to be noticeably more abundant on alfalfa fields on which clover had recently been grown or where manure from clover hay had been applied just previous to the planting of the alfalfa, clover being also subject to severe attack.

Onion smut control. Earlier work on this project demonstrated the success of the formaldehyde drip method in controlling this serious disease. This method, however, requires the use of a large amount of formaldehyde solution per acre. It is troublesome and time-consuming to arrange for the necessary water supply and to stop and fill the small tanks carried on the single-row seed drills every few rods. Especially from the standpoint of the man who is growing onion sets by the multiple row-drill (the usual Oregon system), the difficulties of applying this method are practically prohibitive, a number of growers having abandoned set-growing because of smut, rather than wrestle with the drip method. This situation, as well as the success of the copper carbonate dust method for the prevention of wheat bunt led to a hope that some sort of chemical dust might be applied to the soil in such a manner as to produce satisfactory control without so much difficulty. Accordingly, in the summer of 1922, and again in 1923, attempts were made to control the disease by applying dry fungicides in the furrows at the time of seeding. Copper carbonate and sulfur dusts were used. An attempt was made to adapt a fertilizer attachment on a small seeder for the purpose, but this failed to operate in a satisfactory way. Nevertheless, two things were evident from the tests; first, that with the methods of distributing the dusts which were used, unsatisfactory control of smut was secured when compared with the excellent results of the standard formaldehyde method; second, that copper carbonate caused a marked reduction in stand not experienced with either the sulfur dust or the liquid treatment. During the following winter laboratory experiments were carried forward by pot tests with the same materials. The work was done by a graduate student, J. L. Bedwell, under the direction of H. P. Barss. The results confirmed the field experiments. Sulfur dust mixed with smut-contaminated soil resulted in considerable control, but not approaching that obtained with formaldehyde solution. Sulfur did not retard or repress germination in the least and its presence in the soil entirely prevented damping-off attack which was bad in untreated pots, as did also copper carbonate and the formaldehyde treatments. Copper carbonate mixed with the soil caused very severe reduction in germination and at the same time gave very little protection against onion smut infections. Thus far there seems to be little hope that the dust method can supplant the liquid formaldehyde method for onion smut control.

Dust treatment of grain for smut control. The state-wide tests of copper carbonate conducted by county agricultural agents under the direction of the Experiment Station, and completed with the harvests of 1922 and 1923, proved without exception, that this method is far superior in many ways to the former standard liquid treatments as far as wheat is concerned. There is no injury to seed nor retarding effect on germination, or on the growth of the seedling, such as experienced with formaldehyde and bluestone. The result is prompt emergence and thick, vigorous stands with less opportunity for the establishment of

weeds. The grain does not have to be planted within twenty-four hours, as with the liquid treatments, but may be kept indefinitely after the copper carbonate has been applied, without the least injury. Less seed per acre is required because practically every kernel will grow. In numerous cases growers have failed to reduce their seeding rate enough and have suffered reduction of yields, due to too heavy stands. Observations have shown that where the treating is properly done, smut control in wheat is practically equal to that obtained with the liquid bath, but a special treating machine is required and the mixing process must be continued long enough to insure the complete coating of every kernel with the copper carbonate. Careful precautions have to be taken by the use of respirators, or other means to avoid inhaling the dust, or illness results.

In order to throw light upon a number of questions connected with seed treatment, an extensive series of rod-row tests was begun on the Experiment Station farm at Corvallis in the fall of 1923, and continued the next spring. The results, briefly summarized, are as follows: (1) All the high standard brands of copper carbonate tested (four) containing 50 percent or more of copper and of fine and fluffy quality produced, when properly applied, practically equal bunt control, whether of the "sticky" or "non-sticky" type; (2) all low-standard lots of copper carbonate tested (four) containing only from 10 to 22 percent of copper, gave markedly inferior control of bunt as compared with the high-standard brands when used on wheat that had been heavily smutted artificially, but where the wheat was only lightly smutted, practically complete control was obtained with either type; (3) two ounces per bushel of high-grade copper carbonate thoroughly applied, produced practically perfect bunt control on Jenkins Club wheat artificially smutted as heavily as 1 to 500, 3 and 4 ounces producing no better control, except where the smut was applied to the wheat at the excessive rate of 1 to 77; (4) out of 8 different organic mercury compounds tried out as dusts, two did not give the slightest evidence of smut control, three showed only the slightest degree of smut control, while the remaining three, DuPoint Semesan, Corona 620, and Seed-o-San, proved to have a fungicidal value about equal to the low standard copper carbonate producing good control with the more lightly smutted lots of wheat, but not equalling high-standard copper carbonate with the most heavily smutted samples; (5) nickel carbonate gave very poor smut control; (6) furfural, 1-400, used as a dip with wheat and oats, gave no indication of any fungicidal effect.

Miscellaneous Investigations

Among the minor studies to which some attention was given during the biennium may be mentioned the following:

The effects of sulfur-containing fungicides on canned gooseberries. This work was conducted in 1923 in cooperation with E. H. Wiegand of the Horticultural Products Laboratory, because of the difficulty canners reported with the formation of gas in cans of gooseberries which had been taken from sprayed fields. This experiment disclosed the fact that the presence of either lime-sulfur spray or of sulfur dust on the berries when gathered, would result in gas formation after a period of time in the cans. This led to the recommendation that growers confine protective applications against gooseberry mildew to the period previous

to the setting of the fruit, previous investigations of the Experiment Station having indicated that very successful control could be obtained in this way if the sprays were commenced early enough.

Comparative results with dusts and sprays in apples and pears. This test was continued through the seasons of 1922 and 1923. An experimental program worked out by the Experiment Station was put on in the orchards of the Oregon Apple Company at Monroe, under the direction of B. W. Johnson, Manager. Lime-sulfur, Atomic sulfur, "dry-mixed" sulfur and lime and dusting sulfur were used. Little apple or pear scab made its appearance in any of the trial blocks in either year and there was but little marked contrast between the blocks as regards the development of powdery mildew. Anjou pears showed severe skin injury where lime-sulfur was used, but no such injury appeared where the other materials mentioned were employed. This supports the advice of the Experiment Station that lime-sulfur ought not to be used, at least after blooming, on tender-skinned varieties, but that some non-caustic sulfur-containing spray or dusting sulfur should be substituted.

The control of cheat smut. Many farmers in the Willamette Valley find it desirable to grow cheat *(Bromus secalinus)* for hay crop on certain types of soil, but they have frequently experienced severe attacks of brome smut *(Ustilago bromivora)*, sometimes even in spite of attempted seed disinfection by the standard formaldehyde soak used for cereals. A small treatment test was started in the fall of 1923 on the Experiment Station farm at Corvallis, using rod-rows, replicated. The seed used was from a smutty crop, but was not artificially smutted. The results of the various treatments were as follows: Semesan dusted on the seed in excess quantity, no smut; copper carbonate applied the same way 0.14 percent smut; copper sulfate (blue vitriol) 1 lb. to 5 gal. dip, 0.32 percent smut; hot water 10 minutes at 130 degrees F. after seed had received 5½-hours pre-soak, 0.42 percent smut with some evidence of injury to stand; formaldehyde 1-320, dipped and covered 2 hours, 2.59 percent smut; untreated dry seed (control) 8.5 percent smut; Kalimat 1-400 half-hour soak, 12.8 percent smut; furfural 1-400 half-hour soak, 30.4 percent smut. It is not clear why formaldehyde gave control inferior to the dust treatments especially with a hulled seed like that of cheat. Further tests should be made before final conclusions are drawn, but in view of the results obtained it would be worth while for farmers to test the copper carbonate method where they have a chance to use a dust-treating machine.

An earwig parasite. In the early spring of 1924, specimens of dead European earwigs were received from Mr. Howard Stearns in the employ of the State Board of Horticulture in connection with earwig control. Mr. Stearns noted what appeared to be a fungus growing from the dead bodies, and in tests found that the fungus could be made to infect and kill healthy insects within a short time. Examination and laboratory experiments at the Experiment Station have confirmed the correctness of Mr. Stearns' idea that the fungus is an active parasite. It has been isolated, grown in artificial culture, made to infect and kill uninjured earwigs. It is being given further study, although the conditions favorable for its active propagation among the insects are probably so restricted that it does not promise to become of importance in the biological control of this pest.

DEPARTMENT OF ENTOMOLOGY

This is essentially a report of the progress of the work, for in but a few of our projects have important milestones been reached from which some rather important conclusions can be drawn.

Toxic values of insecticides and the comparative resistance of insects to poisons. Casein spreaders developed by the Oregon Station have now been adopted and approved by many fruit growers because of their effectiveness in film-spread and economy in use of spray material. On the other hand, there is still doubt in the minds of some growers and many technical men as to whether the spreaders increase the toxicity of the spray.

This problem is now being investigated by the department. The sprays to be tested will contain arsenate of lead from the same sample through the tests. Calcium caseinate spreaders and skim milk will be used in the series in order to compare the value of commercial spreaders versus skim milk. Results of tests to date indicate that both spreaders are more effective in preventing the worms from entering through the calyx than lead arsenate without the spreader.

Artificial Propagation and Distribution of Beneficial Predaceous and Parasitic Insects

Work upon this project has been handicapped because of the death of Professor Lovett and consequent reorganization of the department. During the past year, however, the following studies have been prosecuted:

1. Collection and study of the parasite literature.

2. Study of and charting the seasonal data of various foliage-eating caterpillars occurring in Oregon.

3. Collection and study of egg parasites of the tent caterpillar.

4. Rearing parasites from various leaf-feeding caterpillars. By means of egg counts and dissections under the microscope, it was found that from 12 to 15 percent of the tent caterpillar eggs were parasitized by an hymenopterous parasite, species undetermined, possibly *Telenomus* (sp.) according to Dr. L. O. Howard.

Several Tachinid and hymenopterous parasites have been reared from caterpillars including *Nemorilla maculosa,* (M. G.) a tachinid parasite of the thistle butterfly, and *Exorista lavarum* (L.), a tachinid parasite of the Tussock moth.

Tachinid parasites of the earwig. A shipment of about a thousand puparia of *Digonochaeta setipennis* was sent the department from England during the autumn of 1924, and of *Rhacodineura antiqua* during the spring of 1925. This material was secured through Dr. L. O. Howard, Chief, Bureau of Entomology. The costs of collecting and transporting this material are being financed by the city of Portland. The Entomology department has undertaken the work of rearing and increasing these parasites under controlled conditions until sufficient numbers are obtained in order to insure effective establishment of the species when released.

The peach and prune root-borers. This project practically closed except for a few minor points such as effectiveness of paradichlorobenzene against the borers in the spring and its effect upon young trees under four years old. Manuscript is completed for a Station Bulletin.

The peach and prune root-borer *(Sanninoidea opalescens)*, one of the worst insect enemies of the peach and prune, can be easily and cheaply controlled by the use of paradichlorobenzene. This conclusion may be drawn from the experimental work conducted by the Station during the past two years. When applied in early fall with soil temperatures high (above 55° F.) and soil moisture low, paradichlorobenzene will kill 90 percent of the borers. A kill of 65 to 100 percent is reported by the prune growers and county agricultural agents who used this material last year. The results of Dr. Lathrop's experiments for the control of this pest may be found in Station Circular 50, Control of the Western Peach and Prune Root-Borer.

The European earwig. This project was completed during the biennium. At a cost of a few dollars and a little work during a few evenings of the year the European earwig, *(Forficula auricularia)*, can be so reduced in numbers that it is no longer an offensive pest. For control a poison bran mixture, developed by the Experiment Station, is used.

Formula for poison bran:

Sodium fluoride	12 ounces
Molasses	2 quarts
Wheat bran	12 pounds
Water	6 quarts

The results of Mr. Fulton's experiments for the control of this pest may be found in Station Circular 29, Destroy the Earwigs, and Station Bulletin 207, The European Earwig.

Root- and soil-infesting insects. Onion-maggot investigations *(Hylemyia antiqua)* were undertaken seriously this season. Weekly trips were made to the onion fields in the Lake Labish region, Marion county, where studies of various recommended control methods were made as well as observations upon the life-history, habits, and extent of damage.

It was found that the onion-maggot fly lays its eggs in the soil adjacent to volunteer onions and onions planted for seed production many days before the peak of the infestation appears in the field onions. The flies, apparently attracted to a poison bait (consisting of a solution of sodium arsenite, ½ oz.; molasses, 1 pint; water, 1 gal.) sip the liquid with deadly results. Therefore, it would seem feasible to reduce the damage of the onion-maggots by luring them to deposit their eggs near trap onions and after completing their task, partake of the deadly poison contained in a shallow can conveniently placed in the shade of the trap onions. It is hoped that an opportunity will present itself to give this method of combating the onion-maggot a thorough trial next season.

Hop red spider. *(Tetranychus telarius.)* This was a serious pest of hops in 1924, because of unusually dry season. Growers are not satisfied with present control methods. Several experimental controls with dusting and spraying were tried. Lime-sulfur, dusting sulfur, sublimed sulfur, colloidal sulfur, soluble sulfur, oil emulsions, comprise some of the materials tried.

Potato insects. A survey of potato insects has been undertaken with special reference to those that may be responsible for the transmission of virus diseases.

Insect pests of brambles. A survey of the insect pests of brambles has been undertaken this season with special reference to those that may be responsible for the transmission of virus diseases.

Alfalfa weevil survey. Entomologists of the Experiment Station and the Federal Bureau of Entomology examined some one hundred alfalfa fields in eight counties; namely, Wallowa, Wheeler, Malheur, Baker, Union, Grant, Morrow, and Umatilla, to determine the spread of alfalfa weevil.

Alfalfa weevil was found to have spread to certain fields in the vicinity of Baker in 1923. In June 1924 it was found in all localities visited in Baker county east of the old Oregon Trail, and as far north as Keeting, Sparta, and Halfway and in the southern part of the county as far west as Unity. The old Oregon Trail through Baker county seems to be about the extreme western limit in Baker county north of Baker this year.

The weevil was not found in Union county although it appears to be on the threshhold, two miles south of North Powder and on the Powder River tract in northern Baker county.

Miscellaneous Insect Notes

Syneta leaf-beetle. *(Syneta albida.)* This insect continues to be prevalent throughout the Willamette Valley and its damage to cherries appears to be on the increase. The injury consists of small hunks of meat taken out of the young green cherries before the shucks fall. Later as the cherries develop, these wounds become dry and unsightly lowering the quality of the cherry. The injury was greater in 1924 than in 1923 and more apparent in 1923 than in 1922. Spraying with lead arsenate at ordinary strengths does not appear to give satisfactory control. Increasing the strength may burn the foliage. The addition of lime to the lead arsenate solution, however, has been recommended to counteract its tendency to burn. In view of the fact that this operation probably produces a calcium arsenate, it would seem logical to try calcium arsenate as a control for this pest. If an opportunity presents itself, spraying and dusting tests for the control of the Syneta leaf-beetle with calcium arsenate will be undertaken next spring.

The rosy apple aphid, (*Anuraphis roseus* Baker), is responsible for rather wide-spread damage in certain apple growing sections of Oregon. Aphis apples are all too frequent even in orchards where the standard control measures are conscientiously followed. An investigation of this pest with a view to obtaining maximum effectiveness in aphid control under Oregon conditions appears to be necessary.

Strawberry root-weevil. On May 1, 1924, a specimen of a strawberry plant infested with strawberry root weevils was received from Ashland. The plant was heavily infested, as many as 40 grubs being taken from one plant. This is the first report received by the Station of strawberry

root-weevil infestation in Southern Oregon. Much of the entomologist's time is devoted to answering calls for assistance in combating this pest. Adequate control measures are unknown.

Three species of the strawberry root weevils occur in Oregon. *Brachyrhinus ovatus* appears to be the most abundant and has been taken in the counties of Umatilla, Multnomah, Washington, Clackamas and Linn according to records on file in the Entomology department. *Brachyrhinus rugifrons* has been taken in Clackamas county and according to notes made by Professor Lovett, "It promises to be as serious a pest as its dreaded ally, *B. ovatus.*"

Brachyrhinus sulcatus occurs in Multnomah and Umatilla counties. Undoubtedly the pest is more widely distributed than the records show, for this survey was made a number of years ago.

Tent caterpillars. This report would not be complete if mention was not made of the notorious tent caterpillars *Malacosoma pluvialis* and *M. disstria.* These worms got more newspaper space last year than any other Oregon insect. The story of their abundance and their successful encounter with a railroad train appeared on the front page of newspapers published in the far east and southwest. A survey of their egg rings early this spring revealed the fact that some tiny wasp had laid its eggs within the eggs of the tent caterpillar in order that the young of the wasp might feed upon the young of the tent caterpillar. Thirteen percent of the tent caterpillar eggs examined under the binocular contained the larvae of the wasp instead of the larvae of the tent caterpillar.

On April 9 the tent caterpillars began to emerge from their eggshells. Collections of caterpillars revealed the fact that 50 percent or more had tiny white eggs stuck to the skin near their heads. When placed in a suitable cage, the white eggs hatched into tiny maggots.

Cranberry insects. One of the most serious insects of the cranberry in Oregon is the blackheaded fire-worm, *Rhopobota naevana.* In Oregon, at least, this insect apparently is the limiting factor in cranberry production. Whenever this pest is controlled, other conditions favorable, a crop is assured. Uncontrolled, favorable conditions or not, the blackheaded fire-worm destroys the crop. Growers in 1922 lost heavily because of the ravages of this worm. In 1923 those growers who applied intelligently the spray program as worked out by the Federal Bureau of Entomology, obtained a satisfactory yield.

BRANCH EXPERIMENT STATIONS

The branch experiment stations at Astoria, Burns, Hermiston, Hood River, Moro, Talent, and Union continued investigations along the lines of the previous biennium. In some respects the investigations were materially strengthened. The work of each station has been centered as in previous years primarily on the major agricultural problems of the respective agricultural section represented by the branch station. In addition the branch stations have cooperated with the Home Station at Corvallis in a few investigations for solution of problems common to larger sections of the state or the state as a whole. The character of work and the results are stated briefly in the following pages.

JOHN JACOB ASTOR BRANCH STATION, ASTORIA

The Astoria Branch Station as in previous years concentrated mainly on problems related to development of the dairy industry. The introduction and development of satisfactory legumes and problems of soil fertility and drainage are still of first importance in the Coast Region.

Dairy Investigations

The Station maintained its dairy herd of twenty to thirty animals. All milkings were weighted and recorded and records were kept of all feeds and pasture.

The study to determine the effect of grain upon milk and butter-fat production while cows are on pasture was continued. The data again indicate that perhaps the main value of the grain is realized in production the following fall and winter, and that profit from the grain ration with pasture will depend upon relative prices of grain and dairy products. The investigation will not be conducted with the thoroughness desired until the Station is better financed.

Feeding of soiling crops as developed by the Station was further extended in practice. Little additional was undertaken in an experimental way. Results of feeding during the current years and in past years were kept before the dairymen. The three years' results with the Station herd showing a 15 to 20 percent production increase from feeding soiling crops during the summer months apparently is proving true in practice. Much depends upon the price of dairy production, however, average milk production and cost of producing the soiling crops on the individual farm.

Grain rations were again worked out to take utmost advantage of local feeds. The possibility of assistance in this way was presented in the last Report of the Director. Rations recommended meant a saving to dairymen of about $8.00 per ton.

Crop Varieties

Varieties of roots introduced by the Station, including pomeranian White Globe turnip, improved American Purple Top rutabagas, and other varieties continue to show much improvement over old varieties. The Station feeding records under coast conditions indicate that Clatsop county alone should have about one acre of turnips to each 12 producing cows, or about 333 acres of turnips in the county.

As late as 1920 successful growing of oats and vetch as green feed and for use as silage had not been worked out in Clatsop county. By the use of lime, manure, and legume cultures, the Experiment Station has shown remarkable success with vetch and oats. This crop was first grown in 1920, and by 1924 there were approximately 160 acres in the county.

As with vetch, field peas were difficult to grow in the Coast Section, but methods of securing excellent stands have now been worked out. Vetch is used more than field peas, however, because the vetch seed is cheaper.

One of the greatest needs of Clatsop county is for early green feeds. The introduction of Japanese Barnyard millet as a soiling crop

is of great advantage in years like 1924. Green feed in such years is difficult to secure and without it the production of dairy cows may drop 50 percent. By using soiling crops the summer drop in production can be held to 25 to 30 percent.

The test of potato varieties over a number of years has lead to the selection of about three leading varieties for the Coast Section.

For years root production in this section was difficult and uncertain because of damage from root maggot. The Station discovered that by planting susceptible root crops a month or six weeks later than had been the custom, the young plants do not appear above ground until the egg-laying period of the maggot fly is over. By close observations annually, the planting date can be recommended satisfactorily. The Station results have indicated that late planting does not materially reduce the yield under local conditions. Previously farmers occasionally had to plant rutabagas and turnips two or three times. This simple finding has been worth much to the farmers of the Coast Section.

Fertilizers

The results of the biennium indicate still more clearly the value of superphosphate. According to Station results, 300 pounds to the acre at a cost of about $6.00 will increase the average yield of rutabagas seven tons an acre. Rutabagas are worth approximately $7.00 per ton, and there should be about one acre to each 12 producing cows for this section. In 1924 about 60 tons of superphosphate were sold for fertilizer in Clatsop county alone, which indicates that the Station results are being put into application.

Until the past few years farmers of the county could not maintain their clover fields. Station results then began to indicate the need and value of lime and manure on hill land and manure alone on the tide-land. The results of the last two years indicate further that by using lime and manure, clover stands yielding three tons per acre can be maintained, where heretofore the clover died if one or two crops had been harvested. Two car-loads of lime were shipped into Clatsop county in 1924 and applied on 70 acres, which indicates that the Station results are being followed.

The results of the Station work were brought together and published as Station Bulletin 203, Forage Crops for Oregon Coast Counties, May, 1924.

Miscellaneous Service

The superintendent of the Experiment Station has devoted much effort in assisting the dairy association to build up a satisfactory production and marketing program, and has taken a more active part than in previous years in problems of coast agriculture. Special effort was put forth in cooperation with the County Agent to have farmers of the Coast Section visit the Station. This they did in large numbers.

HARNEY VALLEY BRANCH EXPERIMENT STATION

The Harney Valley Branch Station was established in 1911 six miles east of Burns at an elevation of about 4100 feet on typical sagebrush land varying from sandy loam to sandy silt loam or clay loam spotted with alkali. The soil is considered average to poor for the Valley. The average annual precipitation from 1914 to 1924 was 7.81 inches.

The Station was established to study problems of dry-farming and its efforts were confined to this field until 1917. A deep well and pumping plant were installed in 1917 to provide water for irrigation and a study of irrigation problems. Since then problems of irrigation-farming as well as dry-farming have been under study.

Varietal Trials

Varietal trials with wheat, barley, oats, rye, alfalfa, field peas and other crops have been continued, both under irrigation and dry-farming.

Dry-Land Varieties

For dry-land varieties the Station results since 1911 indicate that the best varieties are Early Baart and Hard Federation spring wheat, Turkey Red winter wheat, Hannchen barley, Sixty-day oats, Vern spring rye, Grimm alfalfa, Kaiser field peas, Mammoth Russian sunflowers, and Early Ohio and Early Six-weeks potatoes.

Varieties for Irrigation

The following crops continue to give best results under irrigation: Federation spring wheat, Turkey Red winter wheat, Trebi and Hannchen barley, Silvermine or Swedish Select oats, Grimm alfalfa, Kaiser field peas. The clovers are not well suited to Harney Valley conditions. Mammoth Russian sunflowers produce the largest tonnage for silage. Peas and oats are the best combination crop for the Harney Valley. Early Ohio potatoes have yielded well over a period of years.

Rate and Date of Seeding

Dates of seeding vary about three weeks, depending upon location and season. The following continue to be the most satisfactory on the average:

CROP	RATE OF SEEDING	DATE OF SEEDING
Spring wheat	2 bushels	April 1 to 25
Winter wheat	2 bushels	September 1 to 25
Spring barley	2½ to 3 bushels	April 20 to May 10
Spring oats	2½ to 3½ bushels	April 1 to 25
Spring rye	2 to 2½ bushels	April 1 to 25
Alfalfa	10 to 20 pounds	April 25 to June 1
Clover	10 to 15 pounds	April 25 to June 1
Field peas	1 to 2 bushels	April 1 to 25
Sunflowers	20 to 25 pounds	May 1 to 25
Combinations	2 to 3 bushels	April 1 to 25
Potatoes	1½ to 2 ounce piece per hill	May 15 to 25
Sugar-beets	8 to 12 pounds	May 15 to 25
Mangels	8 to 12 pounds	May 15 to 25
Rutabagas	3 to 5 pounds	April 15 to 25

Tillage Experiments

The tillage experiments were continued with little gain in the way of new information. The main development to date is that the summer fallow should be plowed early in the spring and kept free from weeds.

Rotation Experiments

A number of rotations are being tried out under irrigation. The best results to date are from a two-year rotation, grain following field peas; and a six-year rotation of alfalfa 4 years and grain 2 years.

Fertilizer Experiments

Experiments with fertilizers were started in 1919. Differences in yield are apparent, but the results do not yet warrant any conclusive statement of comparative yields. Manure and manure with acid phosphate appear to give increased yields with the majority of crops.

Duty-of-Water Experiments

Duty-of-water experiments have been under way to determine the amount of water necessary to produce best results both on yield and in net returns for different crops. Results to date indicate best results from 12 to 14 acre inches per season for cereals, 18 to 20 acre inches for alfalfa, 18 acre inches for clover, 30 acre inches for Mammoth Russian sunflowers, 14 to 16 acre inches for field peas, 18 acre inches for peas and oats, 10 acre inches for potatoes, and 12 acre inches for beets and mangels.

Trees and Shrubs

A project was started late in the biennium to test fruit trees, shade trees, shrubs, and small fruits in the hope of finding something, preferably crop-producing, which will aid in beautifying the home grounds and will furnish shade. In cooperation with the Horticultural department of the Central Station at Corvallis, planting stock of all varieties which have promise for this section were secured and planted.

Wheat Nurseries

A wheat nursery was established to test out for this section white winter wheats. No statement of results is yet warranted. A winter wheat smut nursery also was established in 1924. The one year's results are promising, but several years will be required to justify further statements.

Cleaning and Grading Experiment

An experiment previously started to determine the value of cleaning and grading seed for planting was continued. Grade No. 1 was run once over a No. 8 screen; Grade No. 2 twice over a No. 8 screen; Grade No. 3 twice over a No. 8 screen and once over a No. 7 screen. Grade No. 4 was used direct from the separator. They were grown under irrigation, having approximately 18 inches of water. The average yield for the four-year period, 1921 to 1924, inclusive, has been as follows: Grade No. 1, 45.4 bushels per acre; Grade No. 2, 51.4; Grade No. 3, 52.3; Grade No. 4, 44.7—average 48.5 bushels per acre. Further study taking into account additional cost for cleaning and increase in yields will be necessary for conclusions.

Miscellaneous Service

The field days for 1923 and 1924 were successful and well attended, especially is this true of 1923 when practically one-fourth of the citizens of Harney county attended. The Station receives hundreds of telephone calls, letters, and personal visits from interested farmers and business men. The crops grown on the Station under irrigation made a favorable impression on all of the railroad officials, and were a factor in stimulating the construction of the railroad into the Valley.

UMATILLA BRANCH STATION, HERMISTON

The Umatilla Branch Station, located on the Umatilla project of the United States Reclamation Service, is conducted with the cooperation of the Office of Western Irrigation Agriculture of the United States Department of Agriculture. The soil, climatic, and topographical conditions under which the Station is working are typical of those of eight irrigation projects comprising approximately 275,000 acres and of several hundred thousand acres of raw land in the Northwest which will be brought under irrigation in the future.

The Station was established and is maintained for the purpose of investigating the agricultural problems on the sandy soils of the Columbia Basin under irrigation. The work, in general, covers irrigation methods, soil fertility problems, and crop testing with some attention to methods of crop disposal with livestock.

Irrigation Methods

The irrigation of light, sandy soils presented many new problems in irrigation which have received considerable attention at the Station. It was found that ordinary irrigation methods with small streams of water running continuously were not applicable to local conditions on account of the low water-holding capacity of the soil. The border system of irrigation with the use of large heads of water was tried by the Station and, when it was found to be an economical means of irrigation, was introduced on the project. Now a large percentage of the land on the Umatilla Project employs the method and it is coming into general use on the light soils of the Columbia Basin in Oregon and Washington. Since this method was introduced on the Umatilla Project only half as much irrigation water is used per acre as was formerly required. Tests on the proper size of borders show that they should be constructed 30 to 40 feet wide and 150 to 200 feet long, depending upon the size of the head of water available, the character of the soil, and the topography of the land.

As a phase of this work, soils were placed in concrete tanks 3 feet square, with a hole in the bottom to catch the surplus water, and containing 6 feet deep of soil to determine the amount of water which could be economically applied to these sandy soil types without loss from percolation below the plant root zone. These results showed that the coarser types should not be irrigated with over 3 inches of water, the medium types with 4 inches and the finer types with 5 inches per application. The irrigation water applied and the water which leaches through the 6 feet of soil are analyzed to ascertain the plant foods added to the soil by irrigation and washed out by deep percolation.

Soil Fertility

In the study of fertility problems special attention has been given to the value of manure applied to corn and alfalfa and the value of commercial fertilizers. These results show that the soil needs organic matter as much or more than a concentrated plant food. The 9-year average production of alfalfa on a rather coarse sandy soil has been 3.78 tons per acre. Where manure was applied at the rate of 8 tons per acre, 6 years of the 9, the average yield was 5.13 tons and where applied at the rate of 32 tons it was 6.12 tons per acre. The 8-ton application increased the yield 1.35 tons per acre or at the rate of 504 pounds of hay per ton of manure while the 32-ton application increased it 2.34 tons over no manure which was at the rate of 219 pounds per ton of manure, showing very definitely that the lighter application secured the greatest return per ton of manure. When manure was applied to corn at the rate of 8 tons per acre the increased crop yield measured in actual feeding units was only 56 percent as high as when applied to alfalfa and when at the rate of 32 tons, 34 percent.

Crop Tests

Crop testing has included a wide variety of possible crops and has been detailed for the principal crops suitable to local conditions.

In all, 22 varieties of alfalfa have been tried. The results show a variation of 2.29 tons of hay per acre in yield between the highest- and lowest-yielding varieties. The hardy northern varieties all do well but the tender southwestern strains should not be grown on account of winter killing. Grimm has given an average yield of 7.41 tons per acre, while the common strain grown from local seed has yielded 7.31 tons.

The growing of 48 varieties of corn has resulted in the selection of Bloody Butcher as the best variety for general use. This variety is being used extensively on the project since it has been introduced by the Station. The Station keeps the variety pure for a local seed source.

Tests of pasture grasses have developed a mixture of grasses and clovers which under suitable conditions for pastures, that is, on the heavier moist soils, has such a high carrying capacity that pastures have become more profitable than similar areas of alfalfa.

Lamb Feeding

Probably the outstanding accomplishment of the Station during the past two years is the establishment of a lamb-feeding district in the vicinity of Hermiston. During the past two winters the Station has fed each year a car-load of 250 lambs in order to ascertain the practicability of disposing of hay by feeding it to lambs under local conditions rather than selling it off the farm. It has been found that lambs have paid good returns over the market price of hay in addition to such charges as labor, interest, etc., and further, the manure is kept on the farm. The outcome of the showing made the first year was that 3 project farmers last winter each fed a car-load of lambs which gave returns of over double the market price of hay.

Miscellaneous Service

The Superintendent of the Station is available to answer a wide variety of calls for information and the farmers make extensive use of the findings of the Station in this way. During the winter months the Superintendent spends much of his time out on the project with the farmers, helping them with their farm problems such as livestock feeding, the proper crops to grow, and the laying out of their land for irrigation.

HOOD RIVER BRANCH STATION

Apple-Tree Anthracnose

The investigation of apple-tree anthracnose was continued during the biennium.

Bordeaux oil as a dormant spring application was tested together with bordeaux applications applied during different seasons of the year.

Persistence of the copper and its influence on the control of the disease have been determined for these applications.

Final conclusions and recommendations cannot be reached until one or more season's additional tests have been made. Observations thus far indicate that application of bordeaux oil can be effectively used in controlling this disease. Careful observations point to the fact, also, that the addition of the bordeaux does not reduce the value of the oil in controlling leaf-roller, brown apple-aphids, San Jose, and Oyster shell scale. There is a possibility that this combination is not effective in handling the blister-mite.

Scab Spray Investigations

Testing of various materials for apple-scab control was continued. The absence of the disease, however, resulted in tests of limited value. Unfavorable weather conditions for scab development together with wide-spread usage of an effective spray program has greatly reduced the scab infection.

Root-Rot Investigation

The difficulty of conducting worth while studies on this problem due to lack of suitable land and funds was called to attention in the Director's Report for the past biennium. This lack of facilities became further apparent and the project was deferred after 1923 without results of material benefit. The study did bring out the fact that there are at least two strains of causal organism, *Armillaria mellea,* present in the Hood River Valley. The type found on fir land is apparently nonparasitic.

Codling-Moth Studies

The investigations on this subject involved chiefly the determining of useful dates for spray applications. However, the comparative merits of single and double strength of arsenate of lead used with or without a spreader of calcium caseinate are being investigated. Up to the pres-

ent time little benefit is apparent from adding the spreader agency. The investigation will be continued perhaps two more years before conclusions are reached.

Leaf-Roller Investigations

As a result of further observations the conclusion was reached that moderate infestations causing 10 to 15 percent fruit damage, can be economically handled by double strength arsenate of lead (4 pounds to 100 gallons of water), thoroughly applied in the calyx spray. When fruit loss is greater than this, a standard oil emulsion of at least 6 percent has been found most effective and is now recommended. The bordeaux-oil combination also is effective for this pest where equivalent strengths of oil are used.

Blister-Mite on Apples

Blister-mite on apples has made it necessary to undertake control studies. An investigation of the life-history and control measures has been started with the idea of developing control with a minimum change in spraying practices.

Pear Spraying Investigations

Investigations in this field were continued largely to determine the effect of various materials such as lime-sulfur, atomic sulfur, dry-mix lime and sulfur on the fruits of Anjou pear as well as their influence on the control of mildew and scab. Both diseases have been of little consequence during this period making it an impossibility to draw conclusions as to their fungicidal value. Atomic sulfur can be safely used. The value of the dry-mix formula is still uncertain. Work is also started to determine the most effective and economical way to control the pear blister-mite.

Strawberry Root Weevil Control

Owing to the great damage caused by the Strawberry root weevil, the efficiency of the oil barrier method of control as employed in British Columbia was tested, a patch of approximately three acres being used for this purpose. Though the effect of control of the weevils cannot be determined at this time, difficulties encountered in the way of wind and rain as affecting the barrier make maintenance cost very great.

Orchard Fertility Investigations

During the summer of 1923 preliminary cooperative tests were started between the Hood River Experiment Station and the department of Agricultural Chemistry in determining the analysis of typical Hood River soils. These tests indicate clearly that nitrogen is a limiting factor. Sulfur and calcium in some soils are also present in rather limited quantities. Soils are either slightly acid or neutral in reaction. These investigations were supplemented during 1924 by tests bearing upon the percentage of nitrogen available in the form of ammonia and nitrate nitrogen. Analyses were made approximately every two weeks beginning in early April and continuing until late November. Soils provided with cover crops consistently show a higher percentage of nitrate nitrogen than those where this feature was neglected. The tests have a prac-

tical bearing upon the use of supplementary early spring applications of quick acting fertilizers such as nitrate of soda. Some soils, notably Underwood loam, show a high degree of nitrifying capacity. It is interesting to note that as late as May 1, 1924, no nitrate nitrogen was found in the Parkdale loam at an elevation of approximately 1500 feet although the soils were well supplied with humus and ammonia was present in appreciable quantity.

The use of commercial fertilizers in the orchard has been continued. These included one bearing Anjou pear orchard and five bearing Spitzenburg and Newtown apple orchards. In addition, a test was made bearing upon the influence of removing alfalfa hay from a Newtown orchard in comparison with allowing the cut hay to remain or no cuttings whatever. Results, although not conclusive, do not favor the removal of this crop as hay. In the various experiments referred to, nitrogen, phosphorus, and potassium were used alone and in combination. Nitrogen was applied in the form of nitrate of soda, blood meal, and sulfate of ammonia. The practicability of using sheep manure has also been subject to study. The practice of using a quick acting fertilizer such as nitrate has been found economical in view of increased crops. This is especially so on the lighter soil types.

Shade Crop Studies

Observations bearing upon the use of shade crops such as Hairy vetch, different varieties of alfalfa and sweet clover have been made. The use of biennial white- and yellow-blossom sweet clover is meeting with increased favor among fruit growers on account of its quick growth and maximum production of organic matter. Hubam sweet clover (an annual) is likewise meeting with favor for similar reasons. Where ample irrigation water is available, sweet clover apparently possesses an advantage over alfalfa and possibly vetch.

Fertilization of Small Fruits

A number of strawberry fertilizer tests have been in progress for three and four years with the Clark Seedling. This variety is characteristically a "shy" bearer. Various combinations of nitrate of soda, superphosphate and sulfate of potash were used. During 1922, responses from one four-year test in the use of "mixed" fertilizers were practically negligible. This may be largely attributed to the unfavorable short, hot, ripening season. Averages obtained in 1924 favor two equal annual applications, one in spring and the other following the topping season in midsummer. These applications total around 600 pounds per acre.

Cooperative tests were made with the United States Department of Agriculture bearing upon the firmness of strawberries and the character of fertilizer used. No clear cut relationship under the conditions obtaining in 1924 was established.

The influence of topping strawberry plants at different intervals following harvest is being studied.

Preliminary tests are in progress on the fertilization of Cuthbert raspberries. On a light sandy soil type, yields have been greatly increased by applications of nitrate of soda and superphosphate. On a heavier soil type, nitrate of soda and sulfate of potash have given best

results. In both cases the net profit from the use of such fertilization has been unusually high. Further studies are necessary dealing with the problem of manure, cover crops, irrigation and fertilizers as related to firmness and cannery quality. Tests conducted in 1924 do not clearly indicate the influence of fertilizers upon firmness.

Pruning Experiments

Two experiments have been under way. One has to do with fruit spur growth and production in a bearing Newtown orchard in the Lower Valley. The relation of nitrogen fertilizers in different amounts and various types of pruning such as thinning out, heading back, are the basis of this experiment. The test was started in 1922. Results as yet do not warrant conclusions. The other test started in 1922 has a bearing upon the pruning of seven-year-old Anjou trees. This variety is often a tardy and irregular bearer. Trees were winter pruned, summer pruned, or received no pruning whatever. Trees pruned are smaller and have borne lighter crops than those receiving no pruning. Limbs on trees of similar age are being artificially spread by tying down the limbs in order to induce better light conditions. Trees in all plots as yet have borne light crops. Results apparently favor no pruning and tying of limbs of trees of this age. The test was started in 1920. The influence of thinning and heading of old Anjous is also being studied.

Time of Picking Fruit

During 1923 tests were made bearing upon the color and keeping quality of Spitzenburgs and Newtowns when picked early, mid-harvest season, and relatively late. Results generally favor relatively early picking from the standpoint of keeping quality. Newtowns continue to develop in size on the tree relatively late but poorer keeping quality often results together with the possibility of dry rot and red spotting occasioned by excessive rainfall. Spitzenburgs should be picked when the greenish background of "ground color" turns a light yellow color irrespective of red color if keeping quality is to be preserved. No evidence was obtained indicating that the use of nitrate of soda in medium applications as a fertilizer induces poor keeping quality.

Tests have been under way to determine the best time to pick Anjou pears. The common practice has been to pick too early, resulting in a loss of tonnage and failure to secure best eating quality following removal from cold storage. Pears picked from the first to the tenth of October in the Upper Hood River Valley and immediately stored have consistently developed better quality and appearance than those picked considerably earlier. Tests of this character were started in 1920.

Thinning Experiments

Experiments bearing upon the yield and character of Newtowns and Ortleys were conducted in 1922 and 1923. Results clearly indicate that thinning pays in larger yields and more uniform sizes. The work requires keen judgment in estimating the capacity of the individual tree. Ortleys thinned to four inches produced 21.56 loose boxes per tree with only 4.66 percent five tier and smaller as against 17.6 boxes and as much

as 55.8 percent small size where no thinning was done. Newtowns, where heavily set with fruit, respond well from thinning six to eight inches.

Potato Fertilizer

Russett Burbanks (Netted Gem) and Burbank varieties have been fertilized on the Parkdale loam in Upper Hood River Valley. Soil and climatic conditions in this section favor the development of a smooth, high-quality tuber. Yields usually are small where fertilizers are not used. The most economical use of commercial fertilizers has been made only where the soil has been well built up with organic matter as resulting from such crops as clover and alfalfa. Nitrate of soda or sulfate of ammonia combined by weight with superphosphate approximately at the rate of one part of the former with two parts of the latter has given uniformly satisfactory results. Further studies are to be made bearing upon the economy of applying different quantities of the combination mentioned.

THE SHERMAN BRANCH EXPERIMENT STATION

The carefully-planned, long-time experiments in dry-farm crop production at this Branch Station have been continued with no essential changes. The scope of the varietal testing work has been enlarged to include grain nurseries in several Columbia Basin counties for the purpose of determining more accurately the best suited varieties for the varying soil and climatic conditions existing in this territory. This grain nursery work, in most instances, is carried on in cooperation with the county agents. During the past two years more emphasis has also been placed on the cereal breeding investigations. In July, 1923, a competent plant breeder was assigned to this important work at Moro by the Office of Cereal Investigations of the United States Department of Agriculture. The main lines of investigational work at this Branch Station include:

1. Varietal and rate-and-date of sowing experiments with wheat, barley, oats, peas, corn, and potatoes.

2. Cereal breeding investigations mainly with wheat for the purpose of producing high-yielding, disease-resistant, better-quality cereals.

3. Tillage experiments to determine the most economical methods of handling summer fallow for winter wheat production.

4. Soil moisture and nitrate investigations to find out what effect various tillage methods have on the accumulation of nitrate nitrogen in the soil, and the absorption and retention of moisture in fallow land.

5. Crop rotation experiments, mainly to determine what crops, if any, can be profitably grown in systematic rotations with grain on the dry lands of Eastern Oregon.

Varietal Experiments

There will always be need for carefully conducted varietal tests, especially with cereals, in Eastern Oregon. As new and improved varieties are developed, reliable information will be needed in regard to their merits and the locations in which they might prove superior to locally

grown varieties. The Branch Station at Moro has already rendered valuable service in this connection to Eastern Oregon farmers by determining the actual differences in yields of scores of winter wheat, spring wheat, barley and oat varieties; and by increasing and distributing to Oregon farmers seed of high-yielding, meritorious cereals. The Federation spring wheats, for example, first proved and distributed by this Branch Station, have revolutionized the spring wheat industry in Eastern Oregon by substituting two high-yielding, good-milling wheats for the numerous inferior varieties commonly grown. The production of Markton oats, a high-yielding, smut-immune variety, is another distinct achievement of this Branch Station in this line of work. The detailed results of the varietal testing work at Moro are given in the following bulletins, copies of which are still available for distribution: Oregon Station Bulletin 190, Wheat Growing After Fallow; Oregon Station Bulletin 204, Spring Crops for Eastern Oregon; and United States Department of Agriculture Circular 324, Markton, an Oat Variety Immune from Covered Smut.

Smut-resistant varieties. Since the publication of Oregon Station Bulletin 188, The Wheat Bunt Problem in Oregon, announcing the discovery of several immune and highly smut-resistant wheat varieties, three years' data have been obtained on their yield in comparison with present commercial varieties. The results for the three years indicate that of the wheats of the smut-resistant group, White Odessa, Turkey 1571C, and Sherman are the highest yielders. These varieties have outyielded the local Turkey variety from 3 to 10 percent. Out of 33 varieties grown in five dry-farm nurseries in different counties of Eastern Oregon in 1924, White Odessa ranked third in average yield. These smut-resistant and other promising wheat varieties are being further tested in station trials, in the grain nurseries, and by farmers in different parts of Eastern Oregon.

Cereal Breeding Investigations

The assignment of a man especially for this work by the Office of Cereal Investigations of the United States Department of Agriculture, has made it possible not only to enlarge the scope of the cereal breeding work, but also to test many more new hybrids, pure-lines, and varieties in nursery rows. The discovery of new smut-immune and smut-resistant wheat varieties opened a promising field for the development of high-yielding, good quality, smut-resistant wheats. Hundreds of selections from hybrids between the most promising of the smut-resistant wheats and present commercial varieties were grown in 1924 in the second, third, and fourth generations. Many of these new hybrids are not only immune to stinking smut, but also appear to possess all other desirable characters for successful commercial wheats for the Northwest. The continuation of this work should eventually mean the production of a high-yielding smut-immune wheat for each important wheat-growing section of the state.

There is a demand at present in Eastern Oregon for a high yielding, hardy winter barley. About 100 barley varieties were grown in 1924 in yield and winter-hardiness tests. The best of these will be continued in yield trials and the most promising varieties increased and distributed to farmers for further trials.

Tillage Experiments

On the Branch Station at Moro, since its establishement, there have been in progress extensive tillage experiments, planned primarily to furnish information as to how various methods of soil cultivation influence wheat yields. The results of these investigations, which are given in detail in Oregon Station Bulletin 190, Wheat Growing After Fallow in Eastern Oregon, and Bulletin No. 1173 of the United States Department of Agriculture, have been directly responsible for higher acre yields of wheat in the Columbia counties of Oregon and in other dry-farming regions of the Northwest. Positive answers have been found for such troublesome questions as the value of spring and fall disking of stubble, and best time to plow, the right depth to plow, the use of packers, the effect on yield of harrowing winter wheat in the spring, etc. The information obtained in these experiments has done much to put the production phase of the wheat growing industry in Eastern Oregon on a more certain and stable basis.

Soil Moisture and Nitrate Investigations

The results of the tillage experiments have shown that time of plowing and methods of handling the summer fallow have a marked influence on both the yield and milling quality of winter wheat. In order to determine more accurately the real causes for these variations, soil moisture and nitrate studies have been in progress during the past two years in cooperation with the department of Agricultural Chemistry of the Home Station. These studies are about completed and the results will soon be published.

Crop Rotation Experiments

The great desirability of more crop diversification on our dry lands makes it extremely desirable to obtain all possible information on the actual yields of all crops that can possibly be grown, together with the effect on yields and on soil fertility of growing suitably productive crops in systematic crop rotations. Rotation experiments have been in progress on the Branch Station at Moro since its establishment. The results, in detail, have recently been published for the first time in Oregon Station Bulletin 209, Dry-farm Crop Rotation Experiments at Moro. The data presented in this bulletin, while emphasizing the superior crop yields obtained from the small grains on dry lands, show that at least one leguminous crop, field peas, and one cultivated crop, corn, can successfully be grown in rotations with grain on much of the wheat-growing area of Eastern Oregon. Of the many rotations tried with grains and other crops, from the standpoint of profit, the following were the most successful: (1) spring wheat—peas; (2) spring wheat—corn—barley; (3) winter wheat—fallow; (4) winter wheat—peas—winter wheat—fallow; (5) winter wheat—peas—peas; (6) spring barley—fallow.

Service Rendered by Station Employees

Branch Station employees are glad to respond, whenever possible, to calls from farmers for assistance and to the Extension Service and County Agents for help in conducting farmers' meetings and Field Days.

Each year one or more days are set aside for farmers of Eastern Oregon to visit the Branch Station. In 1924, three successful field days were held on the Station and one at each of the grain nurseries in Umatilla, Morrow, and Wasco counties. At the nursery at Eight-mile, in Morrow county, more than 200 persons were present.

SOUTHERN OREGON BRANCH STATION, TALENT

Blight Resistance in Pears

The work to determine which types of pears are susceptible and which are resistant to blight has been in progress during the past ten years. During the first seven years it was found that most of the thirty-four known species of pears are highly susceptible to blight, but that two species, *Pyrus ussuriensis* and *Pyrus calleryana,* contain a high percentage of resistant trees. During the past three years most of the work has been devoted to these two species and to the two other species now most extensively used as rootstocks for our commercial varieties of pears. Every available tree of these four species has been inoculated to determine the percentage of immune, resistant, slightly-susceptible and highly-susceptible trees in each of these four species. The results show that the two new species contain a far greater proportion of resistant trees than do *P. communis* and *P. seriotina,*—the two species heretofore used exclusively as rootstocks for pear trees in America. By using these new species as rootstocks for our future pear orchards, the losses from root blight will be reduced to a minimum.

The degree of resistance and susceptibility to blight has also been determined for practically all the known named varieties of pears. Most of these are highly susceptible, but some of them are much more resistant than others. This information will be of real value in deciding what varieties to plant in the future. Several varieties, including Old Home and Longworth, have proved highly resistant. The fruit of these is inferior, but the trees will prove valuable as blight-resistant stocks when top-worked with better commercial varieties.

Rootstocks for Pears

The Station maintains two stock orchards in which the leading commercial varieties of pears are grown on the five species of pears which appear most promising as rootstocks. This is to determine the character of the graft union, rate of growth, age at which trees come into bearing, productiveness, adaptation to various soil conditions, response to root insects and diseases, and length of life of trees on these various stocks. The old standard French pear stock, *P. communis,* is used as the check or standard for comparison. The oldest trees are only five years old, hence are too young to permit any conclusions. However, marked differences in the vigor of the trees are already apparent. It is highly gratifying that the trees on *P. calleryana*—which is probably important from the standpoint of blight resistance—are the most uniform and the most vigorous. The trees on *P. ussuriensis* are the most variable in size and vigor, part of them being more vigorous than trees on the French stock and part of them smaller.

We have found great variation among the seedlings of any species in their ability to resist blight, and in their vigor. Even the resistant species, *P. calleryana*, contains a considerable number of seedlings which are susceptible to blight. It is evident that we will never be able to eliminate root blight entirely, as long as nurserymen continue to produce the rootstocks from seeds. Furthermore, our trees will show considerable variation in vigor and size and productiveness as long as we use such seedlings for stocks. Orchards uniform in size and vigor and with all trees immune to blight can be produced only on rootstocks which have been propagated from cuttings all of which have been obtained from one desirable blight-immune tree. It now appears probable that root cuttings from such an individual will prove most desirable. Hence this Station has commenced work to determine the possibility of rapidly propagating such selected stocks from root cuttings. The preliminary work indicates that such a method of propagation may prove feasible and very valuable.

Spraying for Pear Blight

Pear blight is caused by a bacterium which lives in the tissues of the plant underneath the bark, and the disease may spread throughout the entire plant from one infection. Hence, spraying for this disease has usually proved of little or no value. During the past two seasons this Station has been conducting spraying experiments to determine whether the number of infections in an orchard could be materially reduced by applying some spray which would repel at least some of the insects which distribute the disease. In 1923, spraying with bordeaux mixture reduced the number of infections very materially. In 1924, the experiment was modified somewhat, with the result that no beneficial effects were obtained. The 1923 spraying program will be followed in the future to determine whether the beneficial results of that season can be regularly obtained or whether the results will vary from season to season, depending on weather conditions.

Flournoy Blight Remedy

During 1924, a blight remedy developed and advocated by Mr. G. H. Flournoy of California was tested at this Station. This treatment consists in thoroughly painting the trunk and bases of the main branches with a preparation developed by Mr. Flournoy. The treatment proved worthless under Southern Oregon conditions.

Pear Breeding

The pear breeding work commenced in 1921 has been continued and enlarged during the past two seasons. The object of this work is to produce desirable new blight-resistant varieties by crossing certain blight-immune Chinese varieties with the best American varieties. The plan is to combine in the new varieties the most desirable characteristics of each of the two parents. The young trees thus produced are growing vigorously and all of those resulting from the 1921 crosses were inoculated with blight in 1924. These show great variation, some proving immune, and others blighting readily. It is hoped that some of the immune trees will produce desirable fruit and valuable new varieties.

Pear Variety Collection

This Station has an extensive variety collection originally consisting of approximately 500 varieties, at least ninety-five percent of which are new to Southern Oregon. Practically all of these have borne several crops of fruit and descriptions are being made and records kept of each variety. Naturally, most of these are proving inferior to the best commercial varieties now grown here. A number are producing fruit of excellent quality and desirable size and appearance, and some of these appear promising commercially. The best of these will be tested more extensively in various parts of this Valley.

Anjou Pollination

The Anjou pear produces fruit of excellent quality and highly profitable marketing characteristics. Unfortunately, it is a very uncertain bearer. Every season it blooms heavily, but some years, and on some soils every year, sheds most of its fruits soon after blooming.

For the past two seasons we have been conducting extensive pollination work to determine whether this defect is due to lack of proper cross-pollination and whether it can be remedied by supplying pollen from any of the numerous varieties in our collection. In 1923, the effect of pollen from one hundred different varieties on the set of the Anjou produced an excellent crop throughout the Valley generally. The work was repeated in 1924, but came to naught as the young fruit was destroyed in this orchard by a severe late frost. The work will be continued in future years with proper provisions made to avoid frost injury. Since there is a large Anjou acreage in Southern Oregon, the Station will render a great service to the industry in case it can determine a satisfactory method for insuring good crops of this variety every year.

Lubricating Oil for San Jose Scale

The San Jose scale is one of the serious pests of our orchards. It is usually necessary to spray the orchards once every year during the dormant season to keep this pest under control. Heretofore lime-sulfur has been used for this spray. This is expensive, very disagreeable to apply, and often does not give complete control. A type of lubricating oil, known as red engine oil, has given good results in some of the apple orchards of the Middle West during the past two years. Its value for San Jose scale on pear orchards in this Valley was tested this year. A young bearing orchard which was heavily infested with scale was divided into two parts, and one portion sprayed with 2 percent and another with 5 percent red engine oil. This was prepared by emulsifying it with calcium caseinate and water. Both the 2-percent and the 5-percent strengths gave perfect results, as no live scales could be found three months after application. The weather conditions were perfect at the time of application and for ten days thereafter, being warm and sunny. It is possible that during wet and cloudy weather this spray may not prove so effective, as it did this season. However, in practically all tests made so far, elsewhere, it has proved more effective than lime-sulfur and far cheaper. We shall continue our work with it and shall recommend it to our growers.

Orchard Practices

Fertilizers. Our experiments with orchard fertilizers, inaugurated several years ago, have been continued during the past two seasons. These consist in determining the value of nitrogen, phosphorus, and potash, separately and in combination, on the growth of trees and yields of apple, pear, and peach trees. On the lighter soils, and in case of old trees also on the heavy soils, nitrogen has proved valuable, markedly increasing the vigor and the yields. This was applied as nitrate of soda, sulfate of ammonia, and dried blood, each proving valuable. The applications of phosphorus and potash have not produced any appreciable effect.

Orchard cover crops. The great need of most of the orchard soils of the Valley is humus and nitrogen. The most economical way to supply these is by growing leguminous cover crops, such as vetch, sweet clover, and alfalfa. The work to determine the best cover crops for our conditions has been in progress since the establishment of the Station. Various legumes have been tested, including all the more promising species of vetches, various varieties of horse-beans, Tangier peas, and others. It has been clearly demonstrated that the Common or Oregon vetch is of little value for the heavy adobe soils, especially during wet and cold winters. It has also been shown that, for these heavy soils, the Hungarian vetch and the Woolly Podded vetch are superior to all others under local conditions. The selection of these varieties by the Station at Corvallis and the introduction of these into Southern Oregon by the Station marked an epoch in orchard cover-crop work and has made successful orchard cover cropping possible.

Since irrigation has become general in orchards throughout the Valley much interest has been manifested in growing a permanent cover crop like alfalfa in the orchards. The Station should begin work at once to determine the value and practicability of this method of soil treatment as compared with clean cultivation combined with winter cover crops, especially on the heavy soils of the Valley and with the amount of irrigation water available. The Station has no orchards at present suitable for this work. Either such an orchard should be provided or the work should be done in one of the commercial orchards in cooperation with some grower.

Orchard heating. It has been thoroughly demonstrated that orchard heating is a necessity and is highly profitable in the pear orchards on the floor of this Valley. Various types of heaters are in use, including the one- and two-gallon smudge pots and the large, expensive Scheu heaters, in all of which oil is burned, and also briquette heaters using briquettes. The Station is comparing the efficiency of these various heaters and fuels. In a test made with the various fuel oils it was demonstrated that there is a marked difference in the burning time and in the amount of residue and slag in the various types. The growers are now using the type which was found most efficient in the Station tests.

Varieties of Wheat

In 1923, the Station introduced the Federation wheat into Southern Oregon. That year, in the Station test, this variety yielded at the rate of sixty-nine bushels per acre on good soil. All the tests made indicate

that this variety will probably prove superior to all varieties of spring wheat grown in this Valley heretofore. With the additional land recently acquired we will be able to extend our work with wheat and test out the most promising new varieties.

New Land

All the land utilized by this Station has been furnished by Jackson county. Previous to this season this consisted of twenty-five acres. This was not sufficient, hence, in the spring of 1924, the county purchased an additional tract of fifteen acres for the Station. This will enable the work to be carried in a more thorough manner. Most of the Station land consists of river-bottom soil and is well adapted to several important lines of investigation now in progress. The Station, however, possesses only a small acreage of the heavy upland clay and adobe soil which is typical of most of the fruit land of the Valley. Several of the most important cultural and orchard problems confronting the farmers of Southern Oregon can be solved only on this type of soil. The Station needs twenty acres of such land.

General Service

The Station renders a real service to the farmers aside from its experimental work. A striking example is that of bringing irrigation to the Valley. When the Station was established only a very small acreage in the entire Rogue Rivey Valley was under irrigation. Owing to the great need of irrigation, the Superintendent has worked vigorously during the past thirteen years for more extensive irrigation. There have been established five large irrigation districts, and the yields of fruit and alfalfa have been more than doubled.

The Station gives advice on various orchard and farm problems. The need for this is very great, since many of the agricultural problems are peculiar to the Valley and many of the ranchers have come from other parts of the country and from other occupations. Furthermore, rapid progress is being made in various phases of agriculture and particularly in the fruit industry. The ranchers are very progressive and are constantly seeking for this information. In fact, the demands made on us for this service often seriously hamper the experimental work. Most of this service consists in answering inquiries. The chief service has been in personal conferences with visitors to the Station, correspondence, and by answering telephone inquiries. As an example, the total number of personal visits to the Station and Station office during 1923 was 930.

EASTERN OREGON EXPERIMENT STATION, UNION

Investigations with Livestock

The work of the Eastern Oregon Experiment Station with livestock for the biennium ending June 30, 1924 is largely a continuation and development of work in progress for several years past.

Fattening steers. Several tests with fattening steers were finished during the biennium and the results of these tests, together with all pre-

vious work done, were presented in Oregon Station Bulletin 193, Fattening Steers, which may be summarized as follows:

Alfalfa hay alone produced a daily gain of .97 pound when fed to two-year-old steers. The steers were given a daily ration of 37 pounds, of which they refused 5 pounds.

Chopping alfalfa hay for fattening steers increased the gains and saved waste. One ton of chopped hay made 13 percent more gain than one ton of long hay. The cost of chopping in these tests was about $3.00 a ton. Under normal conditions this amounts to more than the increased value of the chopped hay.

Alfalfa hay and grain produced 30 percent more daily gain than hay alone. One pound of rolled barley replaced three pounds of alfalfa hay. It made but little difference whether a small ration of grain was fed throughout the entire feeding period or a heavy feed of grain during the latter part of the period.

Alfalfa hay and silage produced 64 percent more gain than hay alone, while the daily feed cost was approximately the same. The steers fed hay and silage were fatter and dressed out more than those fed hay alone. Alfalfa hay and corn silage, or peas and barley silage, made the most economical and satisfactory ration for fattening two-year-old steers for the Western market.

Meadow pasture produced a daily gain of 1 pound during the first month, 2.39 pounds the second month, 2.31 pounds the third month, and .7 pound the fourth month. Steers finished on pasture topped the market.

Management of fattening steers to produce good gains requires that one handle the cattle gently, make feed-yard conditions comfortable, use a good quality of feed stuffs, feed regularly, use care in the selection of the feeder cattle, and feed nothing but good, thrifty individuals of beef breeding.

Growing cattle. In addition to the tests with growing cattle commented upon in the last biennial report and published in Oregon Station Bulletin 182, Growing Steers, there have been under way during the biennium two additional tests each with nine lots with ten cattle in each lot. With the completion of these two tests, all of the work on growing cattle will be summarized and published. In brief, the important points demonstrated by the tests of the biennium are first: That one pound of cottonseed cake for wintering calves furnished sufficient protein and that it is, therefore, unnecessary to feed as much as two pounds, as was done in the previous tests. Second: That four to five pounds of alfalfa hay furnished sufficient protein to supplement a straw ration for wintering purposes and at a considerable economic saving over cottonseed cake. Third: That calves and yearlings fed either alfalfa hay or alfalfa hay and silage and given one-half of what they would eat have held their own in weight and have been very economical producers.

Fattening lambs. One test was completed comparing a mixture of peas and barley, such as is often grown in the higher altitudes of Eastern Oregon, with straight barley as a grain for fattening lambs. The comparison was made both with and without sunflower silage, but all lots received all of the alfalfa hay they would eat. All lots made satisfactory gains, but the two lots on the peas and barley mixture made

10 percent less gain than those on straight barley. The addition of sunflower silage did not materially affect the gains. This silage was fed at the rate of one pound per day. This one pound of silage did not reduce the amount of hay fed in the case of the barley lots, but did reduce it approximately ten percent in the peas and barley lots. This indicates a very low value for the sunflower silage, but this test is not to be considered as entirely conclusive.

Wintering ewes. Two tests were completed in which studies were made of silage in varying amounts as a supplement to alfalfa hay for wintering ewes both before and after lambing. From these tests, the following points were shown: First, one pound of silage in addition to hay was more efficient and less expensive than larger amounts. Second, each pound of silage fed saved approximately one-half pound of hay. Third, the use of silage apparently has some beneficial effect upon the milking qualities of the ewes, but this has not yet been fully demonstrated. All lots, regardless of how fed, were exceptionally thrifty and produced unusual crops of lambs, varying from 136 to 188 percent, with an average of 162 percent for all lots.

Farm flocks. During the biennium, as previously, a farm flock of 100 ewes was maintained on the Station farm and cost records kept. During the first year, the expenses per head, including interest on investment, market price for all forms of feed and pasture, labor, taxes, and depreciation, were $10.63. The income was $20.48. The percentage of lambs this year was 169 percent, 158 of which reached maturity at an average weight of 101 pounds. For the second year, total expenses were $11.85 per head and the income $17.23. In this case, the lambing percentage was 156 percent, of which 151 reached maturity at an average weight of 83.3 pounds.

Fattening pigs. During both years of the biennium, experiments were conducted comparing different pastures as a supplement to rolled barley for growing and fattening pigs. The pastures compared were (1) peas, (2) barley, (3) winter wheat planted in the spring, (4) peas and oats, (5) kale, and (6) winter rye planted in the spring. On the basis of the grain saved these pastures rated in the order given. Only the peas and alfalfa were more economical than the dry lot where the barley was supplemented by tankage. The barley and tankage in the dry lot made the most rapid gains, but the gains made by all lots were satisfactory and all the pigs acquired a high finish.

Field Crops

The investigations with field crops were greatly strengthened during the last part of the biennium.

Varietal tests. Varietal tests, both in plots and field conditions, were continued and strengthened. The first Grimm alfalfa introduced into Oregon is still producing on this Station. The selection and distribution of a pure strain of Forty-fold was a service of real value to farmers. The oat and barley varieties largely grown in the section of Oregon are introductions and selections by the Union Station. Thorough comparative tests of wheats, oats, barley, flax, corn, alfalfa, peas, vetch, root crops, and head lettuce are now under way.

Crop rotations. The crop rotations were expanded during 1924 to include comprehensive tests of all rotations which might have value for this section. Results will be a matter of time.

The fertilizer rotation containing 52 tenth-acre plots was continued. This includes alfalfa, peas, barley, wheat and corn, with and without manure and commercial fertilizer.

Cereal nursery. In the past this Station has produced from breeding and selection, barleys which are now widely grown commercially. Promising new barleys are now under test in plots and under field conditions. The breeding and selection work has been strengthened during the biennium with barley, rye, and wheat.

Costs of production. The Station has about 600 acres of excellent farm land cropped. The cost of each farming operation, the yield and finally the cost of production and comparative cost of production are determined for each crop produced. These data are considered of value in connection with general cost studies over a period of years.

Dairying

The dairy herd of fifteen to twenty milking cows and their offspring are maintained. The feed consumption, pasture, labor, milk production, and cost of production are accurately kept by years for each cow and the herd as a whole. These data are proving of much value in directing attention to the possibilities of dairying and especially to the necessity of eliminating the "boarder" from the dairy herd. The complete record is available to dairymen at all times.

Service

A "Feeders Day" was held each of the past two years while the beef cattle, lambs, farm flocks, range cattle and dairy cattle, and hogs were all on feed. Later when crops are growing the Grange members have held a meeting at the Station and inspected the Station fields. In addition there are constant calls upon the Station for information.